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## ORIGINAL ARTICLES.

### I.—Notes on Specimens collected by Professor Collie, F.R.S., in the Canadian Rocky Mountains.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

(PLATE XVII.)

THE most interesting series of specimens in this collection comes from Desolation Valley glacier, on the southern side of the Canadian Pacific Railway, and east of the watershed. These are: (1) A roughly pentagonal slab, about 9½″ by 7″ and from ¾″ to 1″ thick, of a rather fine-grained quartzite, with some minute glittering crystals, but giving little or no effervescence with cold H Cl. The surface is crowded with wavy cylinders,[1] generally slightly flattened, varying in diameter from about ·55″ to ·15″ (but commonly about ·55″).

Fig. 1.—Burrows on quartzite slab, about one-third linear of original size.

Externally they are rather smooth, and I think slight indications of a 'shell' can occasionally be detected, perhaps about one-twentieth of an inch thick; others seem to consist wholly of white quartzite, apparently a little purer than that of the underlying slab, but as

[1] The markings in all these specimens, unless expressly stated, are in relief.

a rather more flaky yellowish grey material can be detected in the interstices between them they may have been bored in that material.

(2) Another quartzite slab, roughly oblong, on the average about $5\frac{1}{2}''$ by $4''$ and a little thinner, with a slightly more ferruginous coating, has practically identical 'burrows' (Fig. 1). On the underside of each is a rather ferruginous coating or glaze, with some indications of burrows. The material resembles the basal Cambrian quartzite of North-West Scotland in which worm-burrows occur, named *Scolithus*, and figured by Hall,[1] as found there and at the Stiper Stones.[2] Nicholson[3] refers the vertical burrows to one of three genera, *Scolithus*, *Arenicolites*, and *Histioderma*, grouping the more or less horizontal under the name *Planolites* (with three species), which is accepted by Sir J. W. Dawson,[4] who gives a figure from a slab in the Calciferous Sandstone (Tremadoc) of St. Anne's, which appears to be very similar. In the British Museum collection are similar burrows (unnamed) from the same formation, sent by Sir W. E. Logan from the Green Mountains, Vermont. They also resemble the figure of *Planolites* (sp.?) figured by Walcott[5] from the *Olenellus* zone. So I think the burrows on these two slabs may safely be referred to *Planolites*, but shall not venture to suggest a specific name.

(3) Three slabs of a generally similar quartzite are irregular in shape; (*a*) being about $5''$ by $4''$ and $1\frac{1}{2}''$ thick, (*b*) about $7''$ by $3\frac{1}{2}''$, (*c*) about $5''$ by $2\frac{1}{2}''$ (both rather thinner slabs). (*a*) has some *Planolites* burrows on an irregularly undulating surface, with four rudely parallel tapering marks, rather over $1''$ long, in general form something like a *Pteroceras* spine.[6] Similar objects, about seven in number, but in some cases not so well defined, are found on (*b*) (Plate XVII, Fig. 1) with one or two burrow-like marks, but here some are longer, one or two reaching two inches. Both slabs show obscure burrows on their under surface. (*c*) has one of the same (obscure), and near it a small group resembling the markings referred by Sir J. W. Dawson[7] to 'rill-marks,' some obscure worm trails, a bilobed object in relief about $1''$ by $\frac{2}{3}''$ (Plate XVII, Fig. 2), and possibly the impression of another.[8] It is a pointed oval in shape, with a medial depression, like a grain of wheat, which broadens out so as to produce a flattening at each end. I think the spine-like marks may be the tracks of some rather large Crustacean, though I find neither the corresponding set nor the usual central furrow;

[1] Geol. New York, vol. i, p. 2, and pl. i.

[2] "Siluria," 4th ed., p. 40. They also recall those figured by Matthew (Proc. and Trans. Roy. Soc. Canada, vol. vii, p. 159, pl. ix) under the name of *Chondrites* from the Cambrian (basal) of Acadia.

[3] Proc. Roy. Soc., vol. xxi (1872–3), p. 288.

[4] Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 612.

[5] Tenth Ann. Rep. U.S. Geol. Surv., pl. lxi.

[6] The form sometimes slightly resembles, though very much larger than, the marks attributed by Salter to *Hymenocaris vermicauda*, Prestwich, Geology, vol. ii, p. 35.

[7] Loc. cit., p. 545.

[8] It has a faint resemblance to the *Russichnites* of Dawson (loc. cit., p. 597), and to one or two rather similar (but considerably larger) objects in the British Museum collection.

the others may be produced by an animal of the same group, unless they are a peculiar duplication of curving burrows. The underside of the slabs show some ill-marked burrows, and usually the 'glazed' surface already mentioned.

(4) A rather rhomboidal slab of greenish-grey quartzite about 3″ by 2″ by 1″ with a brownish glaze on one surface. On this are little lumps about the size of a small pin's head, four elongated, rudely parallel, slightly curving elevations, somewhat resembling those mentioned above, but barely tapering and so more spine-like; possibly forming part of the same set are three others, which, however, are less regular in shape. On another part of the slab is a single elevation about as thick as a straw, which may be a burrow, and two or three near scarcely thicker than stout pins (once or twice they are in intaglio). Four of these can be detected underlying the first set and crossing them at an angle of about 60°. These are more like burrows, but if so the tendency to be parallel is perplexing. The material of this specimen is more like that of the next one (5), which is a slab rather rhomboidal in outline, measuring about 11″ by 5″, and roughly 1½″ thick (Plate XVII, Fig. 3). From one surface rise a number (about forty) of bosses, dome-like in form, varying in diameter from about ·9″ to 1·1″, not quite hemispherical, owing to a very slight flattening of the upper part of the dome. A faint ring-like marking, produced occasionally by a slight increase of the radius, but also by a similar decrease, is often perceptible. The majority have a slight depression or dimple at the top (occasionally well-marked), as if made by pressure of a blunt-pointed instrument. In one or two cases the outline of the surface seems traceable into the slab for a short distance. These domes occasionally touch one another, once or twice being very slightly flattened at contact. On the slab also are a few worm-burrows, like those described above, a couple of which seem to end abruptly against the exterior of a dome, about as many pass now and then obliquely over the lower part, and one across the top, where it makes a slight depression. All the domes and burrows are coated by a filmy brownish glaze. The opposite side of the slab consists of a greenish grey, rather flinty argillite, on which at one place is a flattened, slightly raised swelling, about an inch each way, something like a bag in shape, and of slightly different texture. This argillite, in about ¼″ or ⅓″, passes rapidly into a ferruginous quartzite of which also the mounds consist, but they, together with the burrows, are apparently surrounded by an irregular thin layer of argillite resembling that on the other side.[1] Besides this slab Professor Collie

[1] By the kindness of Dr. Henry Woodward I have examined the very interesting collection of rock 'freaks' (if such a term be permitted) at the British Museum, but it failed to throw light on these singular structures. They present a certain resemblance to some of the peculiar globular concretions in the magnesian limestone of Durham, which occasionally rise in flattened hemidomes, with a similar slight restriction of the diameter in a horizontal section. But the dents common at the top of the Canadian specimens are wanting, and the latter show no sign of a concretionary structure, which is rare in a sandstone, and so far as I am aware unknown in a quartzite. I find nothing like them in Nathorst's work (Kong. Svenska. Vetenskaps-Akad. Handlingar, xviii, 1881, No. 7), nor in Delgado's Etudes sur les Bilobites, etc.

placed in my hands about half of a mound which had been knocked off its edge, and a fragment of a rather thicker piece of quartzite, slightly paler in colour, on one side of which were two mounds and part of a worm-burrow. I have had a slice cut from the former parallel to the old vertical fracture, and another from the latter in the same direction and practically through the middle of one of the mounds going down about $\frac{3}{4}$ inch into the quartzite. The two are so similar that one description will suffice. They consist of grains of quartz, a few being sharply angular, the majority sub-angular, but a fair number rounded, which are sometimes slightly enlarged by a secondary deposit of crystalline silica optically continuous. They exhibit in size and ordering a faint stratification. I find also two or three small grains of a dull brown tourmaline, two of them rather prismatic in outline and one included in a quartz grain. Another slightly more abundant mineral occurs in grains. rather oval in outline, as well as in not very definitely shaped crystalline granules included in quartz grains; these have a high refractive index, are a dull madder-pink or brownish-purple in colour, and are only faintly pleochroic. At first the polarization tints seemed also dull, but a closer study showed that their natural colour masked a real brightness, and the mineral was a dark zircon. One or two grains of a rather granular dull yellow mineral with crystalline outline resemble sphene more than epidote. Grains or granules of an iron oxide, not seldom limonite, are also present, possibly with two or three of a dark ferruginous rutile. All these are scattered in a fairly abundant matrix, which is mainly composed of a minute filmy mica-like mineral, colourless and with fairly high polarization tints, probably a secondary product after felspar, traces of which can here and there be detected. In the larger specimen we find a green filmy or flaky mineral, doubly refracting, barely pleochroic, with rather dull polarization tints, which is probably a variety of chlorite; in the other one there is less of this, but considerably more of a minute, prismatic, fairly dark green mineral, probably an epidote. Thus the microscopic structure, so far from being favourable, is actually adverse to these mounds having a concretionary origin. They cannot, I think, be regarded as casts of a Cœlenterate like a 'jelly-fish' or any other perishable organism. Professor Collie and myself came independently to the conclusion that they could only be casts of pits made by an annelid, as it retreated from the surface. I remember to have seen pits about this size between tide-marks on a beach, some of which (I was told) were made by a *Solen*, others by a lugworm. These casts, so far as size goes, might belong to *Planolites*, with the burrows of which they are associated, but this annelid generally moves horizontally, being thus distinguished from *Scolithus*, which descends vertically. Mr. Walcott, in his "Fauna of the Olenellus Zone,"[1] gives a tube of *Scolithus linearis* leading to the top of a piece of sandstone, where are the casts of three cup-like depressions, and a "summit view of a group of casts of the cup-like depressions" (the latter being sometimes more irregular in outline

[1] Tenth Ann. Rep. U.S. Geol. Surv., p. 603 and pl. lxiii.

and not very well drawn), which on the whole are very like the Desolation Valley markings, except that they are barely half the diameter. Murchison, in the figure mentioned above, shows the opening of the burrows to be 'trumpet-shaped,' and Delgado ("Etudes des Bilobites," pl. xxxix, fig. 1) represents *Scolithus* burrows with a saucer-like depression at the top about $\frac{1}{4}''$ in diameter, in the middle of which is a low mamelon about half that width at the base. This would produce a depression in a cast, though much larger in proportion than those in the mounds which I have described, but that difference may be due to something in the material. So I think it very probable these mounds indicate 'pit-holes' formed by the retreat into the mud of *Scolithus* or some annelid of similar habits, and that, as remarked above, the pits were already filled, perhaps a little stiffened, when *Planolites* moved among them, or, in other words, that the pit-making worm lived in the mud and *Planolites* rather in the sand. But more evidence is needed before we can speak confidently on this point.

From Desolation Valley glacier Professor Collie also obtained four specimens of darkish slaty rock, all probably more or less calcareous, and one which is practically a limestone, not unlike some dark varieties in the British Carboniferous Limestone. Of two other specimens, one has a very pitted surface of a light reddish colour, resembling a compact dolomitic limestone, perhaps with some admixture of sandy material. Professor Collie states that he finds $CaCO_3$ with some $MgCO_3$, and it effervesces but little with cold HCl.[1] The second, whiter in colour, but speckled with dark green (possibly an iron silicate), is a quartzite.

The last specimen brought by Professor Collie contains rounded and subangular pieces, the former being the larger and occasionally nearly one inch in diameter, scattered rather sparsely in a purplish-red calcareous matrix speckled irregularly with the former material, the weathered surface being very rusty. It consists of carbonates of lime and magnesia, with iron oxide. A microscopic examination shows the pale grey enclosures to be a fine-grained dolomitic limestone containing a few granules of quartz or possibly a silicate; the cementing material of the matrix is also a dolomitic carbonate, but is more irregular in its granular structure. In it two kinds of grains are thickly scattered; one being quartz, varying from subangular to well rounded, some of which, at any rate, may be regarded as wind-worn; the other are more variable in shape, enclosed in a dark ferruginous ring, and occasionally almost wholly stained by it. Some have green centres, which show an aggregate structure with crossed nicols, and are probably a variety of glauconite; others resemble the larger fragments, but are a little finer grained; a few apparently retain traces of a reticulate structure (possibly crinoidal); two or three thin elongated or curved objects may be fragments of mollusca, and one suggests a spiral foraminifer.

There is no precise evidence as to the age of any of these

[1] The chemical notes throughout are the results of Professor Collie's qualitative examinations.

Desolation Valley specimens. Worm burrows and tracks are not very helpful, but *Planolites* appear to be commonly found in rocks belonging to the Cambrian period, ranging from the bottom to the top. Lithological character also is not the safest of guides, but I may remark that both the white quartzites and the slabs with the mounds remind me of Cambrian rocks, the former being not unlike the basal quartzite of Britain, and the matrix of the latter being more altered than is usual in a rock belonging even to the later part of the Cambrian. So I think we may pronounce the quartzites and argillites from Desolation Valley to be not more modern than Lower Cambrian, the limestones probably belonging to a later part of the Palæozoic.

Mount Neptuak (10,500 feet) rises at the head of Desolation Valley glacier, on the watershed between the Bow and the Vermillion Rivers, about 12 miles in a direct line from Hector Pass. A specimen "from the ridge" is a limestone ($CaCO_3$, with a little $MgCO_3$, a very small amount of insoluble residue, and some carbonaceous matter). In colour it is a pale brownish grey, mottled rather irregularly, and in about equal quantities with a darker shade of the same. The microscope shows it to be a very fine-grained dolomitic limestone, mottled by another rather more coarse, its grains varying about ·005 inch in diameter. The finer part is once or twice traversed by a sharply zigzagged dark line suggestive of fracture, and the coarser seems to run up into a crack in the finer material, the latter corresponding with the darker parts of the rock; it also contains a few thin fragments, straight, or hooked, or more or less oval, probably organic, perhaps molluscan. I suspect that the finer-grained rock has been brecciated *in sitú* and subsequently cemented by infiltration.

The remaining specimens come from the northern side of the Canada Pacific Railway, and at a much greater distance from it. Mount Freshfield (about 10,900 feet) is on the watershed where it has bent much to the west. It drains on one side to the Bush River (South Fork), on the other to the Blaeberry Creek, which joins the Columbia River. From the Freshfield Glacier comes a pebble, possibly a rather crushed and decomposed diabase, containing perhaps a speck of sodalite. From near the summit of the mountain are two limestones, each rather curiously marked, one being yellowish ($CaCO_3$ with a little $SiO_2$), indicating, I think, local brecciation and recementation; the other (yielding a white residue and no MgO) possibly due to a similar cause. They have a general resemblance to later Palæozoic limestones.

A specimen from the Bush Pass near Mount Freshfield is an impure limestone ($CaCO_3$ with MgO, and some $SiO_2$ or $Al_2O_3$); it affords dubious traces of organisms and may be Palæozoic.[1]

[1] In 1900 Professor Collie (Geogr. Journ., xvii, 1901, p. 268) brought a few specimens from pebbles in the bed of the Bush River, some distance away to the west. One is a limestone with oolitic grains recrystallized; another contains fragments of organisms, ill preserved; two show a coral which, according to Mr. E. T. Newton, F.R.S., probably in one case, certainly in the other, belongs to the genus *Diphyphyllum*.

A specimen from a "washout beneath Forbes," at the junction of the stream from the Freshfield Glacier with the valley from Bush Pass, which runs ultimately into the Saskatchewan River, is a black cherty-looking rock, harder than the knife (insoluble in H Cl, but with faint traces of $Ca C O_3$). This, under the microscope, exhibits rather more minute granules and rhombs of a carbonate (probably dolomite) than I should have anticipated; its general colour being a very pale brown. The slice is crowded with small clear organisms, about ·005 inch in length, sometimes cylindrical, which on examination with a high power prove to be siliceous. The material is occasionally doubtfully colloid, more often of minute crystalline granules, with occasional local replacement by calcite or dolomite. Believing these to be sponge spicules, I submitted the slice to Dr. G. J. Hinde, F.R.S., to whom I am indebted for the following note: "These are rod-like bodies, showing traces of an axial canal, which I feel certain are sponge spicules, and I should also refer the confused mass of fragmentary rods to spicules, but they are now so much altered that it is impossible to recognize if any of them belong to lithistids" [I had suggested the possibility]. He adds: "I have a slice of chert or cherty limestone from the Durness Limestone of Sutherland which is not unlike your section, but the spicules are more distinct and the rhombs of calcite or dolomite less crowded than in the Canadian rock." The slice is traversed by wavy dark-brown lines (? infiltrated cracks).

The specimen from a peak south-east of Mount Lyell and west of Mount Sullivan, at the head of the Valley of the Lakes (which drains to the North Fork of the Saskatchewan), is a calcareous conglomerate ($Ca C O_3$, no Mg O), consisting of rather flat, subangular to rounded fragments, none exceeding ·75 inch, of a pale grey compact limestone in a yellowish calcareous matrix. Examination with the microscope shows the fragments to be varieties of a limestone, generally slightly dirty in aspect, occasionally a little speckled with a dark brown (? bituminous) material, and crowded with minute fragments of organisms (not to be identified with certainty) and small round grey spots (about ·0025 inch in diameter), probably oolitic. There are also a few small grains of quartz. The matrix is more or less stained with limonite, contains many fragments of organisms, similar but larger; some showing traces of prismatic structure, and probably molluscan; some perhaps Brachiopods; some also possibly calcareous sponge spicules.

Mount Forbes (about 12,000 feet) is also to the south-east of Mount Lyell, but to the south of Mount Sullivan. A specimen from near the summit is a dark limestone, containing Mg O as well as Ca O, not unlike some British Carboniferous limestones.

Mount Howse (about 10,800 feet) is in the same district, but to the E.S.E. of the last peak, and on the watershed, where it suddenly changes from a N.N.W. direction to a south-west one. The summit is a compact darkish grey limestone (mostly $Ca C O_3$, with a little $Mg C O_3$ and a blackish residue after solution in H Cl) with one or two small white enclosures, and a few thin veins of calcite,

weathering with a rather irregular, lumpy surface. Examination under the microscope shows it to be a rather fine-grained limestone, slightly discoloured (probably by a bituminous material which may be also represented by a few scattered granules). The veins and enclosures are a coarser calcite, especially the latter, in which the grains are about as large as in ordinary crystalline limestones. No organisms are recognizable.

From Mount Noyes (10,000 feet), about 5 miles east of Mount Howse, we have the following specimens:—(1) A dark limestone (picked up on a glacier) resembling some British specimens from the Carboniferous system, and containing a silicified coral like a Lithostrotion. The fossil is not well preserved, but Mr. E. T. Newton, F.R.S., who has kindly examined it, tells me he is almost certain it belongs to the genus *Diphyphyllum*, which, as he remarks, leaves the age uncertain, as it has been found in both the Carboniferous and the Silurian. (2) A darkish limestone with damaged trilobites, in regard to which Dr. H. Woodward kindly furnishes the note appended to this paper.[1] (3) The summit rock is an impure limestone ($Ca\,C\,O_3$, with traces of $Mg\,O$ and a good deal of insoluble residue), with some small irregularly rounded enclosures, which may be either fragments or casts of bivalves, but on the whole I incline to the view that the rock retains traces of organisms. It has a general resemblance to later Palæozoic limestones in Britain.

From the Canyon of the Bear Creek, which runs between Mounts Howse and Noyes, comes a dark limestone ($Ca\,Mg\,C\,O_3$), with nothing about it to suggest the possibility of ascertaining a date.

Mount Murchison (11,100) lies roughly east of Mount Lyell, and well to the east of the watershed between Bear Creek and the Saskatchewan River.[2] The summit is a pisolitic limestone ($Ca\,C\,O_3$ with a little $Mg\,C\,O_3$); oblately spheroidal bodies in diameter from half an inch downwards, of a darkish grey colour, indicating on weathered surfaces a concentric structure, being set in a light yellowish or brownish matrix. The pisolites under the microscope consist of a rather muddy limestone containing a few specks of quartz or a silicate, also brown granules and possibly a very few fragments of small organisms. They exhibit a rough concentric, but no radial structure, and in one or two places something resembling a minute branching suggests traces of *Girvanella*. In the matrix, which is not very different, except that it consists of larger and more translucent grains, we find granules (? bituminous), a few quartz grains, one or two of which show a crystalline outline, oolitic grains with traces of radial structure, often having small fragments of an organism as a nucleus, and several bits of shell, most of them probably bivalves, but one or two possibly Gasteropods. In one case the structure resembles that of an echinoderm (? crinoid).

Mount Hector, which is about ten miles from the pass of that name, and on the eastern side of the watershed (being almost north

[1] Professor Collie informs me that it was found "just above the bands of Cambrian quartzite, the same as occurs on Mount Hector and elsewhere."

[2] It is some ten miles N.N.W. of Mount Noyes.

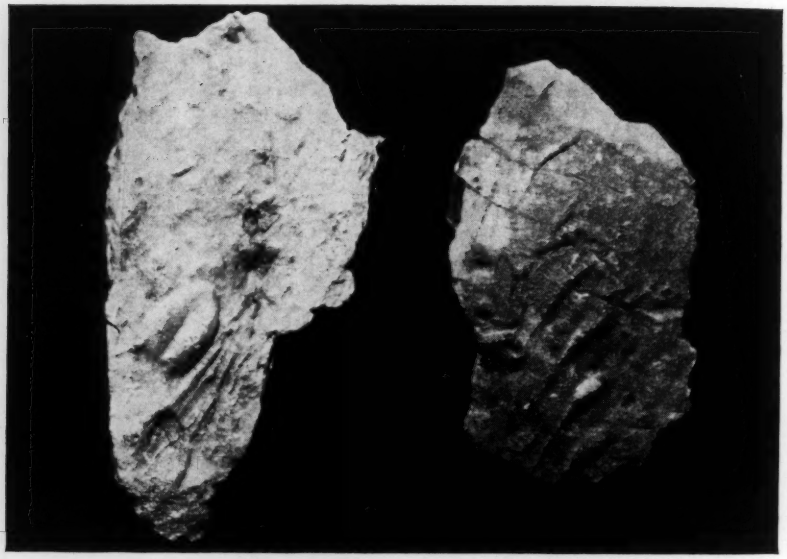


FIG. 2. FIG. 1.

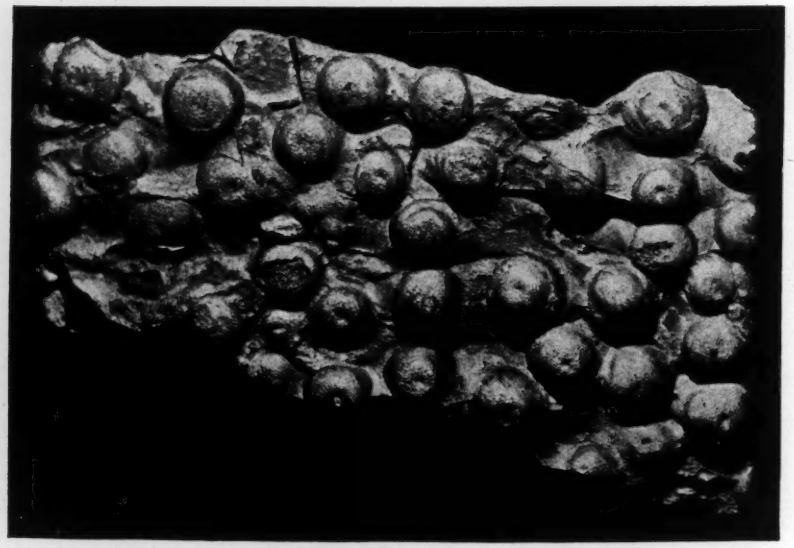


FIG. 3.

Markings on Quartzite Slabs from the Canadian Rocky Mountains.

of Laggan), is represented by a light-coloured fine-grained quartzite, which was collected from directly below the summit and on its western side. It might very well be from one of the older Palæozoics.

In Professor Collie's collection, as in that made by Mr. Whymper, well-preserved organisms are rare.[1] Several of the limestones in the former are in the same mineral condition as those described from the latter one, so that it seemed needless to have them sliced, and I may refer to what I have already said.[2] No doubt a closer search will discover occasional localities with well-preserved fossils such as that on Mount Stephen, but I anticipate that in this part of the Rocky Mountains (nearly 60 miles in length), as in some of the Alps, there will be considerable districts of sedimentary rock in which fossils are absent or barely recognizable.

EXPLANATION OF PLATE XVII.

Fig. 1.—Slab of quartzite, with spine-shaped markings. About 7 inches by 3½ inches.

Fig. 2.—Slab of quartzite, with bilobed marking. About 5 inches by 2½ inches (broader part).

Fig. 3.—Slab of quartzite, with mounds. A very little has been excluded from each end of the block in taking the photograph. It is about one-third linear of the original.

(Fig. 3 by permission of the Royal Geographical Society.)

Note on some Fragmentary Remains of Fossils from the upper part of Mount Noyes (Canadian Rockies). By H. Woodward, LL.D., F.R.S.—The specimens (reproduced in the accompanying diagram about twice natural size) lie scattered over the weathered surface of a thin and somewhat worn, hard, black, slaty rock, in character not unlike that so rich in Trilobites from Mount Stephen (B.C), (see Geol. Mag., 1902, Dec. IV, Vol. IX, pp. 502–505). After much hesitation, on account of the imperfect nature of the materials at my disposal, I venture, with some reserve, provisionally to place these remains as follows:—

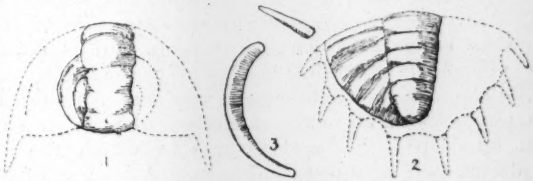



Fig. 1.—*Olenellus ? Thompsoni*, Hall: Bull. U.S. Geol. Surv., No. 30 (1886), p. 167. Walcott, Olenellus Zone: 10th Rep. U.S. Geol. Surv., 1889, p. 635, pl. lxxxii, figs. 1, 1*a*; pl. lxxxiii, figs. 1, 1*a*, *b*. A glabella with four pairs of furrows, a raised and rounded anterior border, one fixed cheek, and indication of the left eye and cheek are also seen upon the surface of the slab. A fragment of another head is present, but is too imperfectly preserved for determination.

[1] For the exceptions see Dr. H. Woodward's paper in last year's volume of this Magazine, p. 502. My report will be found at p. 544.

[2] Ibid., p. 549.

Fig. 2.—*Olenoides*, sp. ? Walcott, Fauna of the Lower Cambrian or Olenellus Zone: 10th Rep. U.S. Geol. Surv., 1899, p. 752, etc., pl. xciv, fig. 1. This genus is represented by an imperfect pygidium, in size equalling *Olenoides Fordi*, Walcott. The border is wanting, but a single spine lies near the left anterior margin, which may have been a marginal spine of the pygidium or a detached median spine.

Fig. 3.—*Helenia bella*, Walcott. Two or three elongate, narrow, flattened, curved tubes may be seen upon the surface of the same slab, one of which is reproduced in Fig. 3. It resembles a specimen figured by C. D. Walcott (Fauna of the Olenellus Zone: 10th Ann. Rep. U.S. Geol. Survey, 1889, pl. lxxviii, fig. 4), which he names *Helenia bella* and refers provisionally to the Dentalidæ.

## II.—Notes on Ocean Island (Banaba).

By F. R. Cowper Reed, M.A., F.G.S.

OCEAN ISLAND, which is also known as Banaba or Paanopa, lies in the Pacific west of the Gilbert group, in lat. 0° 52′ S., long. 169° 35′ E. Our knowledge of it is but scanty; Darwin[1] briefly mentioned it, and it is not the same Ocean Island as Dana[2] described, for the latter lies in lat. 28° 25′ N. and long. 178° 25′ W. It may be therefore of some interest to record a few notes on a small collection of specimens of phosphatic and coral rocks made on it by Capt. R. Tupper, R.N., of H.M.S. "Pylades," who hoisted the British flag there in the year 1900. I am also indebted to him for a description of the island, and to the Pacific Islands Company, Ltd., for kindly furnishing me with further particulars of its physical features and analyses of the phosphatic rocks.

The island is of subcircular shape, with a circumference of about six miles at high-water mark; along its southern side there is a shallow concavity known as Home Bay, bounded on the west by Lilian Point, and on the east by the longer and more prominent headland known as Sidney Point. Except along a small portion of this bay the island is surrounded by cliffs from 12 to 30 feet high, and soundings show that very deep water extends close up to them. The interior forms an elevated tableland rising to a height of about 260–270 feet, with a few surface depressions. The whole island consists entirely of coral formation, and is covered with extensive phosphatic deposits worked by the above-mentioned company. The coral-rock is much weathered, rising in places into high pinnacles and prominent masses of peculiar shapes, and is seamed by deep gullies and fissures in which the phosphatic deposits attain their greatest thickness. A boring of 29 feet in one place failed to pierce them. It is stated that there is a sharp line of demarcation between the phosphatic material and the underlying coral-rock, but some of the specimens submitted to me show that the former has infiltrated and impregnated the latter. The rocks are in many cases of detrital origin, being composed of fragments of calcareous rocks cemented together into a more or less compact mass. One specimen is a coarse breccia; another is

[1] Darwin: "Coral Reefs," 3rd ed., 1889, p. 217.
[2] Dana: "Corals and Coral Islands," 3rd ed., 1890, p. 361.

an irregular conglomerate of rounded or subangular fragments or grains of various shapes and sizes. Recognisable remains of organisms are very rare, but under the microscope a few fragmentary foraminiferal shells can be distinguished in a thin section. The cementing material is a hard pale yellowish or brownish substance of a semi-translucent and resinous appearance, which encases the fragments and lines or more or less fills up the interstices between them. In one specimen the grains are of fairly regular size, and represent a coral sand, converted into a fine oolite by each grain being surrounded by concentric coats of the same cement, and the whole mass thus bound into a solid and compact rock which rings under the hammer. Under crossed nicols a thin section shows that the coats consist of a series of regular concentric layers with a fibrous radial structure, like Renard [1] has described in the oolitic calcareous rocks of Ascension Island. In these examples from Ocean Island we find all degrees of coarseness in the oolitic structure—from a coarse pisolite to a very fine oolite; and in some specimens the cementing material is in excess of the included grains and forms the mass of the rock, losing then its radial structure and behaving under the microscope as an almost isotropic groundmass. The cement in all cases effervesces scarcely at all or but feebly with acid, and is of a phosphatic nature. A completely different type of phosphatic rock consists of regular narrow bands of a yellowish or brownish substance of a semi-translucent resinous appearance. This agate-like rock is very tough and heavy, and has a sub-conchoidal fracture. It seems to consist entirely of the cementing phosphatic material found in the above-mentioned oolites, and behaves in a similar fashion with acids.

One mass of coral (*Mæandrina*) is encrusted with stalactitic deposits of the brownish phosphate which surrounds the corallites, and has more or less obliterated their structure round the margins. Irregular mammillary or stalactitic forms of the phosphate are also met with, and sometimes they enclose patches of fine soft calcareous mud with a hard porcellanous fibrous coating of a bluish or buff colour. One specimen seems to represent the soft calcareous mud of the ancient lagoon, and it now forms a tough fine-grained chalky limestone of a white or buff colour with a conchoidal fracture. Under the microscope minute irregular fragments or broken prisms of calcite are seen to be scattered through it. In another specimen this consolidated mud is banded by brownish layers of a homogeneous opaque substance, not effervescing in the least with acids, and apparently representing original layers of deposition. A fragment of calcareous tufa with the typical arborescent and cavernous structure is present in the collection, but it has a hard brownish phosphatic crust.

The detailed distribution and relations of these various types of rocks have not been studied, and I have no precise information as to their mode of occurrence. The guano which has led to the formation

[1] Renard: "Challenger" Reports, Physics and Chemistry, vol. ii, Rep. Rocks, p. 71.

of the phosphates on Ocean Island is no longer being deposited there, but at what period it ceased is a matter of speculation, though the present condition of the deposits suggests that a considerable time must have elapsed. On many other islands in the dry central parts of the Pacific, such as Howland's, Jarvis', Baker's, and Malden's Islands, guano deposits occur and are still forming, as Dana[1] and others[2] have described.

By the courtesy of the Pacific Islands Company, Ltd., in furnishing me with Dr. Voelcker's analyses of the phosphates of Ocean Island, I am able to state that representative samples show an average of 86·57 phosphate of lime, 2·26 carbonate of lime, 0·21 oxide of iron, and 0·31 alumina.

A complete analysis by Dr. Voelcker of one sample of "hard rock," exported as phosphate, is as follows :—

| | |
|---|---|
| Organic matter and combined water ... ... ... | 1·30 |
| Phosphoric acid ... ... ... ... ... ... | 39·53 |
| Lime ... ... ... ... ... ... ... | 52·54 |
| Oxide of iron ... ... ... ... ... ... | ·15 |
| Alumina ... ... ... ... ... ... ... | ·26 |
| Magnesia, etc. ... ... ... ... ... ... | 4·50 |
| Carbonic acid ... ... ... ... ... ... | 1·62 |
| Insoluble siliceous matter ... ... ... ... ... | ·10 |

(Sample dried at 100° C.)

The coral-rocks and phosphates of Christmas Island, which Dr. C. W. Andrews has kindly allowed me to examine, appear to be of a different character to those from Ocean Island. Mr. J. Stanley Gardiner, M.A., has kindly examined the two fragmentary corals in the collection presented to us, and has identified them as belonging to the genera *Mæandrina*, E. & H. (? subgen. *Cœloria*, E. & H.), and *Orbicella*, which he states are both widely distributed in the Pacific at the present day, and are among the most important of the reef-builders.

## III.—On some *Isochilinæ* from Canada and elsewhere in North America.

By Professor T. Rupert Jones, F.R.S., F.G.S.

Among a large number of Canadian fossils sent to me by Col. C. C. Grant, of Hamilton, Ontario, for transmission to the British Museum (Natural History Branch), there were three particular specimens of fossiliferous limestone worthy of careful examination. These came from a glacial drift at Hamilton, known as 'Bala Drift.' There being no real 'Bala' strata in Canada, the appellation of 'Bala Drift' at Hamilton applies to a glacial drift containing fossils more or less allied to those of *Bala*, most probably to the Trenton Limestone, a Lower Silurian (or Ordovician) formation.

[1] Dana: "Corals and Coral Islands," 3rd ed., 1890, pp. 318–324.

[2] Hague: Amer. Journ. Sci., ser. II, vol. xxxiv (1862), p. 224. Julien: ibid., vol. xl (1865), p. 367.

I. *Isochilina gregaria* (Whitfield), var. *Ulrichiana*, nov. (Figs. 1*a*–*b*.)

No. 1 is a specimen of fine-grained, compact, grey-blue limestone, retaining part of the smooth surface of a suboval pebble, perhaps originally about four inches long. The broken surface (of the split?

Fig. 1.—*Isochilina gregaria* (Whitfield), var. *Ulrichiana*, nov. (*a*) Right-hand valve. (*b*) Dorsal edge. Magnified 3 diam.
Figs. 2*a*, *b*.—Another specimen of the same. Magnified 3 diam.
Fig. 3.—*Isochilina* sp., ind. Crushed. Magnified 2 diam.
Figs. 1–3 from a drifted (Trenton?) limestone at Hamilton, Ontario.

pebble) shows one good example and two smaller indications of a smooth, black, and shiny species of *Isochilina*, which I regard as a modification of *I. gregaria* (Whitfield), Bull. Amer. Mus. Nat. Hist., vol. ii, p. 58, pl. xiii, fig. 3.

It is an imbedded bivalved carapace, showing its dextral valve, ovate-oblong, narrower and more convex in front than behind.[1] Marginal rim strong on the posterior, ventral, and anterior borders. Surface black, smooth, shiny, and very delicately punctate. It has a broad mid-dorsal depression (nuchal notch), bordered by a low semicircular ridge, composed of four tubercles of irregular size; the two largest touch the dorsal edge, and are united below by one round and two oblong smaller tubercles.

This nuchal sulcus approximates in the pattern of its border to that in *Isochilina gregaria* (Whitfield).

The length of the valve is 8 mm., height 6 mm. It is in the specimen No. 1, 'Bala Drift,' Hamilton, Ontario.

Ia. *Isochilina gregaria* (Whitfield), var. *Ulrichiana*, nov. (Figs. 2*a*–*b*.)

No. 2 specimen is a piece of limestone similar to that of No. 1, but darker. One face appears to have been artificially flattened and

[1] This anterior convexity is unusual.

smoothed; and the other presents a broken surface, showing one good Ostracod valve, like that of No. 1, but smaller, together with two still smaller, but allied, specimens, and some indeterminable fragments.

Smaller than Fig. 1, and of similar outline, but with less protrusive postero-ventral curvature, and more convexity in the posterior moiety of the surface of the valve. Differences in the superficial convexity of *Isochilinæ* are shown in figs. 1–6 of Professor Whitfield's pl. xiii, 1889.

The tubercular border of the nuchal notch partly remains, one tubercle on one side and two on the other.

Length 8 mm., height 5 mm. In specimen No. 2, 'Bala Drift,' Hamilton, Ontario.

II. *Isochilina gregaria* (Whitfield), var. (?).

Small bivalved carapace, much like Nos. I and I*a* in shape, subovate, convex in the middle of the valve.

Length 3½ mm., height 2 mm.

III. *Isochilina*, sp.? (Fig. 3.)

No. 3 is a limestone similar to that of No. 2, but coarser and evidently full of organic fragments. One surface is flat and smooth, probably the natural surface of a glaciated rock. The other face exhibits an internal cast of an Ostracod valve, probably an *Isochilina*, somewhat distorted by pressure. Among the accompanying obscure little organisms is a small *Beyrichia* (?) or *Tetradella*.

This cast of a somewhat crushed valve is larger than either Nos. I or I*a*; suboblong, with marginal rim; surface somewhat undulating, having been distorted by pressure. Depressed across the hinder moiety of the valve with a gentle curve. An obscure indication of the base of a broken spine near the posterior margin.

Length 10 mm., height 7 mm. 'Bala Drift,' Lake Shore, Winona, Ontario.

IV. *Tetradella* (?), sp.

The little Beyrichian (?) individual (length 2 mm., height 1½ mm.) on the specimen No. 3, 'Bala Drift,' Lake Shore, Winona, Ontario, with its narrow lobes, although obscure, bears evidence of having a long semicircular thin ridge along the ventral region, just within the ventral border, giving rise apparently to three ridges stretching across the central area towards the dorsal edge. This form may be said to be allied to *Beyrichia Marchica*, Krause,[1] and *Beyrichia Busseacensis*, Jones,[2] and more particularly to E. O. Ulrich's *Tetradella subquadrata*, Journ. Cincin. Soc. Nat. Hist., vol. xiii, pt. 1 (1890), p. 115, fig. 2. All of them belong to the Lower Silurian series.

Some Lower Silurian (probably Chazy) specimens from Ottawa (Ontario), Canada, were referred to in the Quart. Journ. Geol. Soc.,

[1] Zeit. d. D. Geol. Ges., 1889, p. 19, pl. ii, figs. 9–11.

[2] Quart. Journ. Geol. Soc., vol. ix (1853), p. 160, pl. vii, figs. 5 and 6; and Biv. Entom. Geol. Assoc., 1869, p. 15, figs. 23*a–b*.

vol. xlvi (1890), pp. 545, 550, and 551, as *Isochilina Ottawa*, Jones.[1] Variety, (1) occurring abundantly on the bed-planes of a piece of thin-bedded limestone, from a large block in Sussex Street, Ottawa, and probably belonging to the Chazy formation (upper portion); (2) constituting, with a few bivalve Mollusca, the greater part of an easily broken grey limestone from Nepean, Ontario, Canada, belonging to the Chazy formation. Both were sent from Canada by Mr. Henry M. Ami, F.G.S., of the Canadian Geological Survey.

We have to note that the specimens of *Isochilina Amiana* and its variety *insignis*, described by Mr. E. O. Ulrich in the Journ. Cincin. Soc. Nat. Hist., 1891, pp. 180 and 181, pl. xi, figs. 12*a–c* and 13, were also derived from a piece of Chazy rock found by Mr. H. M. Ami in Sussex Street, Ottawa, and given by him to Mr. Ulrich; and they are therefore from the same source as that of the variety of *I. Ottawa* mentioned above. It was carefully illustrated as var. *intermedia* in the Contrib. Canada Micropal., part iv (1891), pl. x, figs. 10*a–b*, 11*a–b*, and a copy of this plate had been forwarded to Mr. Ulrich, as explained in the footnote at p. 181 of his memoir above mentioned. Mr. Ulrich was satisfied, according to that footnote, that the figures named by me *Isochilina Ottawa*, var. *intermedia*, must have been drawn from such specimens as his *I. Amiana*; indeed, both came from Mr. Ami, of Ottawa, as fully explained.

The Ostracoda in the hand-specimens from Hamilton, Nos. 1 and 2, very definitely represent the group of *Isochilinæ* allied to *I. Ottawa* and *I. gracilis*, enumerated in the following catalogue of the known *Isochilinæ*, many of these being either allies, subspecies, varieties, or mutations of *I. Ottawa*, especially those marked "1–13," the many minor differential features being rarely sufficient to separate them specifically.

### Catalogue of the known *Isochilinæ*.

1856. *Leperditia margineta* (?), Keyserling [afterwards *Isochilina grandis*, Jones]: Ann. Mag. Nat. Hist., ser. II, vol. xvii, p. 91, pl. vii, figs. 14*a–d*.

(1) 1858. *Leperditia* (subgenus *Isochilina*) *Ottawa*, sp. nov.: Ann. Mag. Nat. Hist., ser. III, vol. i, p. 248, pl. x, figs. 1*a–c*. Calciferous Sandrock, Grenville, Canada. And Geol. Surv. Canada, Org. Rem., 1858, p. 97, pl. xi, figs. 14*a–c*.

(2) 1858. *Leperditia* (subgenus *Isochilina*) *gracilis*, sp. nov.: ibid., figs. 2*a–d*. White House Papers. Trenton Limestone or Bird's Eye Limestone: Isle Jesus, Canada. And Ann. Geol. Surv. Canada, Org. Rem., 1858, p. 98, pl. xi, figs. 15*a–d*.

(3) 1860. *Isochilina gracilis*, Jones: Month. Microsc. Journ., vol. iv, pp. 185 and 191, pl. lxi, figs. 18*a–c*. Lower Silurian: Canada.

1881. *Isochilina grandis*, Jones [*non* Schrenck]: Ann. Mag. Nat. Hist., ser. v, vol. viii, p. 347.

1881. *Isochilina Jonesi*, Wetherby: Journ. Cincin. Soc. Nat. Hist., vol. iv, p. 42, pl. ii, figs. 7 and 7*a*. Trenton Limestone: Kentucky.

[1] Ann. Mag. Nat. Hist., April, 1858, p. 248, pl. x, fig. 1—not so well figured there as on later occasions.

1883. *Leperditia* (*Isochilina*) *armata*, Walcott: 35th Report N.Y. State Museum Nat. Hist., p. 7, pl. xvii, fig. 10. Bird's Eye and Black River Limestones: Herkimer Co., N.Y.

(4) 1884. *Isochilina Ottawa*, Jones: Ann. Nat. Hist., ser. v, vol. xiv, p. 345. Chazy Limestone, 5 miles west of L'Orignal, and Calciferous Sandrock, Grenville.

(5) 1889. *Primitia* [*Isochilina*] *gregaria*, Whitfield: Bull. Amer. Mus. Nat. Hist., vol. ii, p. 58, pl. xiii, figs. 3–5. Calciferous formation: Cave Island, Ball's Bay, Vermont, Lake Champlain.

(6) 1889. *Primitia* [*Isochilina*] *eristata*, Whitfield: ibid., p. 59, pl. xiii, figs. 1 and 2. With the foregoing.

1889. *Primitia* [*Isochilina*] *Seeleyi*, Whitfield: ibid., p. 60, pl. xiii, fig. 6. Limestone: Shoreham, Vt., and Providence Island, Lake Champlain.

1890. *Isochilina lineata*, Jones: Quart. Journ. Geol. Soc., vol. xlvi, p. 21, pl. ii, figs. 5*a–b*, 8*a–b*. Hamilton Group: N.Y. State.

1890. *Isochilina* (?) *fabacea*, Jones: ibid., p. 22, pl. ii, fig. 11. Hamilton Group: Lake Erie, N.Y.

1890. *Isochilina Seeleyi* (Whitfield), Jones: ibid., p. 22, pl. i, fig. 7. Bird's Eye Limestone (?): Shoreham, Vermont, and Providence Island, Lake Champlain.

(7) 1890. *Isochilina gregaria* (Whitfield), Jones: ibid., p. 22, pl. i, figs. 9 and 10. Calciferous Sandrock formation: Cave Island, Ball's Bay, Lake Champlain, Vermont.

(8) 1890. *Isochilina eristata* (Whitfield), Jones: ibid., p. 23, pl. i, fig. 8. Cave Island, as above.

(9) 1890. *Isochilina* (?), sp., Jones: ibid., p. 23, pl. i, fig. 15. Cave Island, as above.

1891. *Isochilina grandis*, Jones, var. *latimarginata*: Contrib. Micropal. Canad., 1891, p. 78, pl. x, figs. 1–4. Silurian: Manitoba and Saskatchewan.

(10) 1891. *Isochilina Ottawa*, Jones, var. *intermedia*, nov.: ibid., p. 66,[1] pl. x, figs. 10, 11. Chazy to Lower Silurian or Cambro-Silurian.

1891. *Isochilina Whiteavesii*, nov.: ibid., p. 68, pl. x, fig. 13. Trenton Limestone, Lorette.

1891. *Isochilina Amii*, nov.: ibid., p. 68, pl. x, fig. 14. Trenton Limestone, Lorette.

1891. *Isochilina labellosa*, nov.: ibid., p. 69, pl. x, fig. 19. Chazy Series, Aylmer, Quebec, and Bird's Eye and Black River Limestones, Carleton, Ontario.

1891. *Isochilina subnodosa*, Ulrich: Journ. Cincin. Soc. Nat. Hist., vol. xiii, p. 177, pl. xi, figs. 7*a–c*. Upper Trenton Limestone: Perryville, Kentucky.

1891. *Isochilina Saffordi*, Ulrich: ibid, p. 178, pl. xi, figs. 10*a–d*. Upper Trenton Limestone: Nashville, Tennessee.

1891. *Isochilina ampla*, Ulrich: ibid., p. 179, pl. xi, figs. 8*a–d*. Upper Trenton Limestone: Nashville, Tennessee.

1891. *Isochilina Jonesi*, Wetherby: Ulrich, ibid., p. 179, pl. xi, figs. 9*a–c*. Upper Trenton Limestone: Harrodsburg, Kentucky.

1891. *Isochilina Kentuckyensis*, Ulrich: ibid., p. 179, pl. xi, figs. 11*a–d*. Upper Bird's Eye Limestone: Kentucky.

(11 & 12) 1891. *Isochilina Amiana*, Ulrich: ibid., p. 180,[2] pl. xi, figs. 12*a–c*; and var. *insignis*, Ulrich, p. 181, pl. xi, fig. 13. Upper Chazy (?): Ottawa, Canada.

(13) 1903. *Isochilina gregaria* (Whitfield), var. *Ulrichiana*. Figs. 1 and 2 in this paper. Trenton (?) formation, in Glacial Drift, Hamilton, Ontario.

[1] The definition of varieties is carefully given at p. 67, and the localities enumerated.

[2] Footnote at p. 181: "Since the above was written I have received from Professor T. Rupert Jones proofs of the plates which have been prepared for the Geological Survey of Canada. On plate x I notice figs. 10*a* and 11*a*, because I am satisfied that they have been drawn from specimens of *I. Amiana*. These figures are marked '*I. Ottawa* variety,' but for the reasons stated above I cannot accept this designation for my specimens."

## IV.—The Circular Form of Mountain Chains.

By Philip Lake, M.A., F.G.S.

I AM a stranger in the field of speculation, and am quite unacquainted with the intricacies of its authorized boundaries. It is therefore with some hesitation, lest I should tread upon forbidden ground, that I venture to offer a suggestion on one point in Professor Sollas's paper on "The Figure of the Earth."[1]

It has long been observed that mountain ranges and chains of islands (which, indeed, are only mountain ranges partially submerged) are generally curvilinear in form, but Professor Sollas is, I believe, the first to show clearly that the curve often coincides almost exactly with an arc of a circle. Such a mountain chain is frequently defined along its convex margin by a great reversed fault over which the mountain mass has slid forward; and in these cases, at least, we may safely adopt Suess's conception, and look upon the chain as the crumpled edge of a 'scale' of the earth's crust which has been pushed forward over the part in front of it.[2] The surface along which the movement has taken place is called a thrust-plane. If this surface really is a plane, then the edge of the 'scale,' that is the mountain chain itself, must necessarily be circular in form; for if any plane cuts a sphere, in any position whatever, the outcrop of the plane on the surface of the sphere will always be a circle. There can be no deviation from the circular form unless the 'sphere' is not truly spherical, or the 'thrust-plane' is not a true plane. On the scale of an ordinary globe the earth is sensibly a sphere, and therefore any deviation which is visible on such a globe must be produced by a deviation of the surface of movement from a true plane.

Further, in the case of a circular mountain range it is possible from the form of the arc to determine the dip of the basal thrust-plane; for it is easy to show that the angle which a plane makes (at its outcrop) with the surface of the sphere is equal to the angular distance, measured on the surface of the sphere, between the centre and the circumference of the circle formed by the outcrop of the plane.[3]

Thus, for example, the centre of the Himalayan arc is placed by Professor Sollas in lat. 42° N. and long. 90° E., and the angular distance from this point to the arc is 14°. This, then, is the angle

[1] Quart. Journ. Geol. Soc., 1903, p. 180.

[2] The very beautiful sections of the outer Himalayas given by Mr. Middlemiss (Mem. Geol. Surv. India, vol. xxiv, pt. 2) illustrate the process in operation, and in the North-West Highlands of Scotland we have the actual base of such a mountain chain exposed to view.

[3] It should be noticed that a spherical surface also, if it cuts a sphere at all, will necessarily have a circular outcrop. No other form of surface, I believe, has a similar outcrop, excepting only in certain definite positions. A cylindrical surface, for example, will crop out in the form of a circle, if its axis coincides with a diameter of the sphere, but not otherwise. If the thrust-plane be a portion of a spherical surface, it is impossible to determine its dip from an inspection of its outcrop alone.

which the basal thrust-plane must make with the surface at its outcrop.

It is not, however, to be expected that the angle thus deduced from the form of the mountain chain will agree with the dip of the boundary fault along its foot; for in a modern mountain chain the actual base will seldom be exposed, and the faults which are visible at the surface probably bear the same relation to the main thrust-plane that the minor thrusts in the North-West Highlands bear to the major thrust-planes of that region. It is only when the mountain chain has been dissected to its very base that we can hope to see the surface on which the main movement occurred.

If I were to attempt, on this view, an ideal representation of the Himalayas, I should draw, some little distance below Middlemiss's Section VI, a thrust-plane making an angle of 14° with the horizontal. The resemblance of the structure of the chain to that of the North-West Highlands would then be conspicuous. Most of the faults which are visible at the surface would appear as minor thrusts, but it is possible that the great thrust-plane which brings the crystalline schists upon the later beds was at one time the basal plane of the range.

I have no desire to argue that all mountain ranges lie upon the outcrops of thrust-planes, or that there is necessarily a thrust-plane wherever Professor Sollas has drawn one of his small circles. But it remains certain that if a thrust-plane is a true plane, its outcrop on the globe must be an arc of a circle, and that some mountain chains are defined along their convex margins by thrust-planes. Here, then, we seem to have an explanation of some of Professor Sollas's small circles.

Postscript.—After the proofs of this short note had left my hands it occurred to me that the Calcutta earthquake of 1897 might throw some light on the existence of the basal thrust-plane which I have imagined in the Himalayas. It appears from Mr. Oldham's valuable memoir on the subject that the earthquake originated in Assam and not in the Himalayas themselves; but it is interesting to find that Mr. Oldham compares the structure of the Assam Hills with that of the North-West Highlands of Scotland, and believes that the earthquake was caused by a movement along a major thrust-plane of low dip, accompanied by displacements along the more steeply inclined reversed faults which reach the surface.

## V.—Post-Glacial Beds at Dundee.

By James Durham, F.R.S.E., F.G.S.

In the recently published volume of the Memoirs of the Geological Survey of Scotland, "The Geology of East Fife," by Sir Archibald Geikie, it is argued that since the time when the 100 feet terrace was under the level of the sea there has been no depression of the land in the Firth of Tay, only "a continuous chronicle of gradual, if intermittent, uprise" (p. 321); also that

"no trace has survived of any late deposit overlying the peat, so that we cannot be absolutely sure of the position which this sheet of vegetable matter would occupy if all the Post-tertiary deposits of the district could be grouped in chronological order" (p. 318).

In the face of this statement by such a high authority it seems to be very desirable that the details of a section in post-Glacial beds, exposed in digging the foundations of the new Post Office in Dundee, should be recorded in the pages of the GEOLOGICAL MAGAZINE.

As the readers of this Magazine are probably not all familiar with the recent geology of the Firth of Tay, it may be well to state briefly the chronology of these comparatively recent deposits heretofore usually accepted.

At the close of the Glacial Period, or at least when the glaciers had mostly withdrawn from the sea-level, the land stood more than 100 feet lower than at present; the floor of the sea at that time is represented now by a much denuded plateau of sand and gravel, and by a well-worn beach shelf, which indicates a prolonged rest of sea and land at that level; besides the sand and gravel of which the plateau is mainly formed, excavations often bring to light huge boulders which could only have come into their present position by being floated there, which would seem to show that some of the fading glaciers at times reached the sea and detached masses of ice sufficiently large to float these boulders, and, melting, dropped them where they are found.

A slow but apparently uninterrupted upward movement of the land then took place, until it stood about 50 feet lower than at present, when another prolonged rest is indicated by a well-marked beach shelf; between that and the present sea-level the most important beach is that at 25 to 30 feet above the present, but between these beaches there are indications of what seems to have been relatively short rests in the movement. During the long time since the 100 feet terrace, as it is called, was under the sea, denudation has removed a very large proportion of it; especially is this the case in estuaries and river-valleys.

In the Firth of Tay a forest grew on the denuded surface of the 100 feet terrace beds. This forest is represented by a bed of bluish clay in which are entombed roots, trunks, and branches of trees with hazel-nuts; also fragments of insects and sometimes bones of deer are found in this bed; the nuts are much flattened, as if they had been subjected to great pressure under a superincumbent load. This forest bed is found at different levels all over the Firth of Tay, and at some points is seen to pass under low water. This used to be taken to prove that the land stood higher in the time of the forest than it does now, and naturally so, as it is difficult to imagine a luxuriant growth of trees and bushes flourishing fourteen feet below high-water mark in this broad arm of the sea.

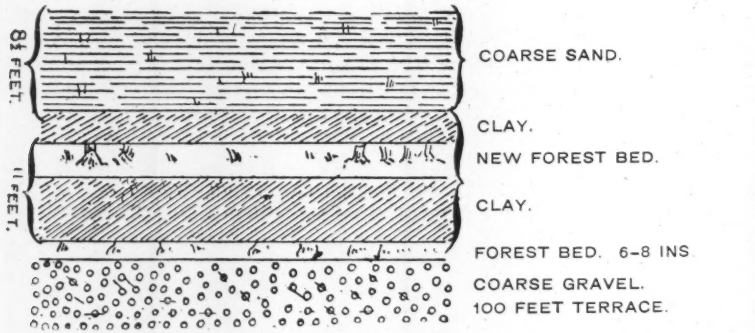
In the upper parts of the Firth of Tay and the Earn another bed or series of beds is found rising some 30 or 40 feet above the present sea-level; these beds consist of clay, sand, and silt, and are known as the Carse Clays.

Now it is clear that if the Carse Clays are laid down on the top of the forest bed, not only had the land stood higher than at present in the first instance, but had been subsequently depressed at least to the level of the top of the Carse Clays, as these are evidently sedimentary deposits in the waters of the Firth.

It is stated on the most reliable authority that in excavations and well-borings in the Carse of Gowrie the forest bed has been repeatedly penetrated. (See Professor James Geikie's "Prehistoric Europe," pp. 391, 392.)

In digging the foundation of the new Post Office at Dundee, a section was exposed which seems to throw a valuable light upon the question as to the succession of these beds, for here we have "deposits of the district grouped in chronological order." The situation of this section is about a quarter of a mile back from the natural foreshore of the Firth (docks and similar works extending far out into the estuary); between the section and the shore a ridge of rock runs for a considerable distance parallel to the margin of the Firth; like the post-Glacial beds to the north of it, it is completely covered by buildings, and like them is only exposed during excavations in connection with alterations and rebuilding in this the centre of the most ancient part of the city.

The level of the street in front of the Post Office is 38 feet above Ordnance-datum. Allowing for the thickness of the blocks and bedding of the street, the top of the section is approximately 35 feet above that base-line, just about the average height of the Carse Clays in the upper part of the Firth. As the total thickness of the beds exposed would be about 25 feet, the bottom of the section would be a little above the present reach of the tide.




Section exposed in digging the foundations of the new Post Office, Dundee.

The excavation revealed the following succession of strata:—At the bottom some five or six feet of coarse gravel, the denuded remains of the 100 feet terrace, then six or eight inches of the far extending forest bed, as usual much compressed; this is succeeded by 11 feet of clay, above which is 8½ feet of coarse sand.

I was indebted to the Inspector of Works for the measurements, so that they may be accepted as absolutely reliable.

An interesting and previously unobserved feature is revealed by this section of the Carse Clays: an upper bed of trees and bushes occurs a little above the middle of the clay, the roots extending for a considerable distance downwards, while the evenly bedded clay of more recent deposit completely buries it several feet deep before the conditions that caused the deposit of the coarse sand supervened.

The occurrence of this upper forest bed would seem to indicate that there had been an interruption of the subsidence, or even re-elevation of the land, during the deposition of these clays, to admit of the growth of the trees and shrubs that form this bed.

That there is good ground for assuming that the gravel exposed at the bottom of the section represents the 100 feet terrace is supported by the records of a deep well-boring made a little to the westward of the Post Office. After passing through similar beds of sand and clay and some 10 or 12 feet of gravel, it, before entering the rock, encounters some 8 or 10 feet of tenaceous blue clay, undoubtedly the Till resting on the surface of the Andesite rock of the district.

With the well-boring and the Post Office excavation, we have a complete series of the Glacial and post-Glacial beds superimposed one on the other: Till, 100 feet terrace, forest bed, and Carse Clays. It seems to me that here we are "absolutely sure of the position which this sheet of vegetable matter *does* occupy."

## REVIEWS.

I.—The Zones of the White Chalk of the English Coast. By A. W. Rowe, M.D., F.G.S. Parts I (Kent and Sussex), II (Dorset), and III (Devon); with plates and sections. Published in the Proceedings of the Geologists Association, vol. xvi (1900), vol. xvii (1901), and vol. xviii (1903).

(PLATES XV AND XVI.)[1]

WITH the publication of his third paper (on the Chalk of the Devon coast) Dr. Rowe has completed his description of the four chief accessible sections through the Middle and Upper Chalk which are to be found in the cliffs of our southern coast. His papers are doubtless in the hands of most of those who are interested in the Chalk and its fossils, but there may be a few readers of this Magazine both at home and abroad who have not seen them, and in any case it seems fitting that such a series of papers should receive some notice, if only because they deal so fully with the zonal distribution of fossils in the Chalk of Southern England that they merit attention both from the palæontologist and the geologist.

In the introduction to his first paper, Dr. Rowe is careful to define the point of view from which he attacks the subject. He says:

[1] [Permission to reproduce the two plates which accompany this article (Plates XV and XVI) has been granted by Dr. A. W. Rowe, F.G.S., the author of the paper, Professor H. E. Armstrong, F.R.S., who is the author of the photographs, and by the Council of the Geologists' Association, who published Dr. Rowe's memoir.—Edit. Geol. Mag.]

"the writer pins his faith to Zoology, and to Zoology alone, for whi
it is true that broad lithological features give us a natural divisio
line between certain zones in some localities, it is equally clear th
these same features fail us in the case of identical zones in oth
districts; but the fossils never fail us if we collect with sufficie
care." This is doubtless true in the case of a coast-section, whe
a long tract including several zones is exposed and every bed
accessible, but it is not true of inland sections, which are usual
isolated quarries or short railway cuttings, often much obscured
talus, and only accessible at certain points. In such places foss
do often fail us, as Dr. Rowe will find if he ever essays to carry
researches inland.

The value of Dr. Rowe's work lies in his demonstration that
ordinary cliff-section of Chalk affords ample material for the esta
lishment of zones and for their exact local delimitation. Incidentall
of course, he has recorded much valuable stratigraphical informatio
and has largely increased our knowledge of the fossils of the Engli
Chalk. There are, indeed, few workers who are both willing a
able to devote themselves to the systematic collecting of foss
from every accessible foot of a long series of beds; few men wou
voluntarily spend all their vacations in collecting thus exhaustive
from one set of beds, while members of the Geological Survey cann
do so, because they are primarily surveyors and have to give mo
of their time to the work of mapping. If instead of a mere foss
collector the Survey had a field-palæontologist, a man of scienti
training who ranked equally with the surveyors, the descriptive wo
of the Survey would undoubtedly be improved.

To produce good stratigraphical work there should be organis
collaboration between the surveyor and a palæontologist, unless th
two capacities are combined in one man. In appreciating Dr. Rowe
work we must remember that he does not put it forward as strat
graphical work; he calls his papers *zoological*, but inasmuch as th
deal with zones they are essentially stratigraphical, and only wa
stiffening with a little more lithological detail to make them comple
stratigraphical studies. As it is, his descriptions are frequent
incomplete because he omits to notice obvious lithological peculiaritie
Thus the zone of *Rhynchonella Cuvieri* near White Nothe is dismisse
in eight lines, and the same zone as shown at Mupe Bay in six line
although its lithology is abnormal and interesting. I point this o
simply because the work he has done is so good and so full of deta
that one regrets he did not include what would have made it a finish
study.

In reviewing the papers which have suggested the above remark
we shall briefly notice the salient points of each. In his first (
the Chalk of the Kentish coast) he commenced with the Marga
Chalk, and showed that the zone of *Marsupites* is divisible into tw
bands or sub-zones, a lower characterised by *Uintacrinus* and
upper to which *Marsupites* is restricted, and he has since found th
this subdivision holds good throughout the south of England. Th
next critical point was the discrimination of the zones of *Micrast*

*coranguinum* and *M. cortestudinarium*, and this he was only able to accomplish after a detailed study of the genus *Micraster*, the results of which were published elsewhere. He places the junction, not where *Micraster præcursor* and *M. cortestudinarium* are first found in the descending succession, but where certain special forms of these species come in and are associated with *Holaster placenta*, *H. planus*, and some other fossils.

In the same way a careful collecting of fossils foot by foot enabled him to fix approximate limits to the zones of *M. cortestudinarium* and *Holaster planus*. Here I may remark that Dr. Rowe seems to have been under the impression that the term Chalk Rock had been applied by some previous writer to a certain part of the zone of *Hol. planus* at Dover; possibly he misunderstood some expressions in Mr. W. Hill's paper on the Middle Chalk of that place; in any case Mr. Hill and I agree with him that no true Chalk Rock exists there.

Dr. Rowe's work in Sussex was fruitful in new results. The zones of *Holaster planus*, *Micraster cortestudinarium*, and *M. coranguinum* were defined and distinguished by means of the essential features of the tests of the Micrasters; but though it is very interesting to know that this can be done by reliance on the forms of *Micraster* alone, it is obvious that some other means of delimitation must be adopted inland when a sufficient number of Micrasters cannot be obtained, and I doubt whether the zones will remain permanently as defined by Dr. Rowe. This, however, is a question for the future.

With the zone of *Marsupites* we are on safer ground; neither *Uintacrinus* nor *Marsupites* had previously been found on this coast, in spite of special search for them. Professor Barrois had assigned far too great a thickness to this zone in Sussex, and he had never properly defined it. The actual limits within which Dr. Rowe found the plates of these Crinoids was a thickness of $77\frac{1}{2}$ feet, but above this there is a thickness of 20 feet which he regards as more properly included in this than in the overlying zone, and I have his authority for stating that this 20 feet was omitted by mistake in the tabular measurements on pp. 333 and 336. The total thickness of the zone is therefore $97\frac{1}{2}$ feet, and the exposed portion of the *Actinocamax quadratus* zone at Seaford Head only 150 feet.

Finally, in this paper he established the zone of *Actinocamax quadratus* on a firm basis as one of the chief zones in the English Chalk, showing that it contains a fauna which is distinct from that of the zone of *Marsupites* below, and from that of *Belemnitella mucronata* as developed further west. At the same time he pointed out that the prevalent Belemnite is not *A. quadratus*, but *A. Merceyi*, which he has since identified with the *A. granulatus* of Blainville.

Dr. Rowe's second instalment was on the Chalk of the Dorset coast, and this paper is illustrated by eight excellent photographs of the cliffs, and two maps on the scale of 6 inches to a mile, drawn by Mr. C. D. Sherborn. The plates show what can be done by means of photographs and key-slips to illustrate the stratigraphical detail of a cliff-face, and a comparison of the text with that of the Survey memoir on the same area shows how much more information can be elicited by a careful collection of fossils from the Chalk.

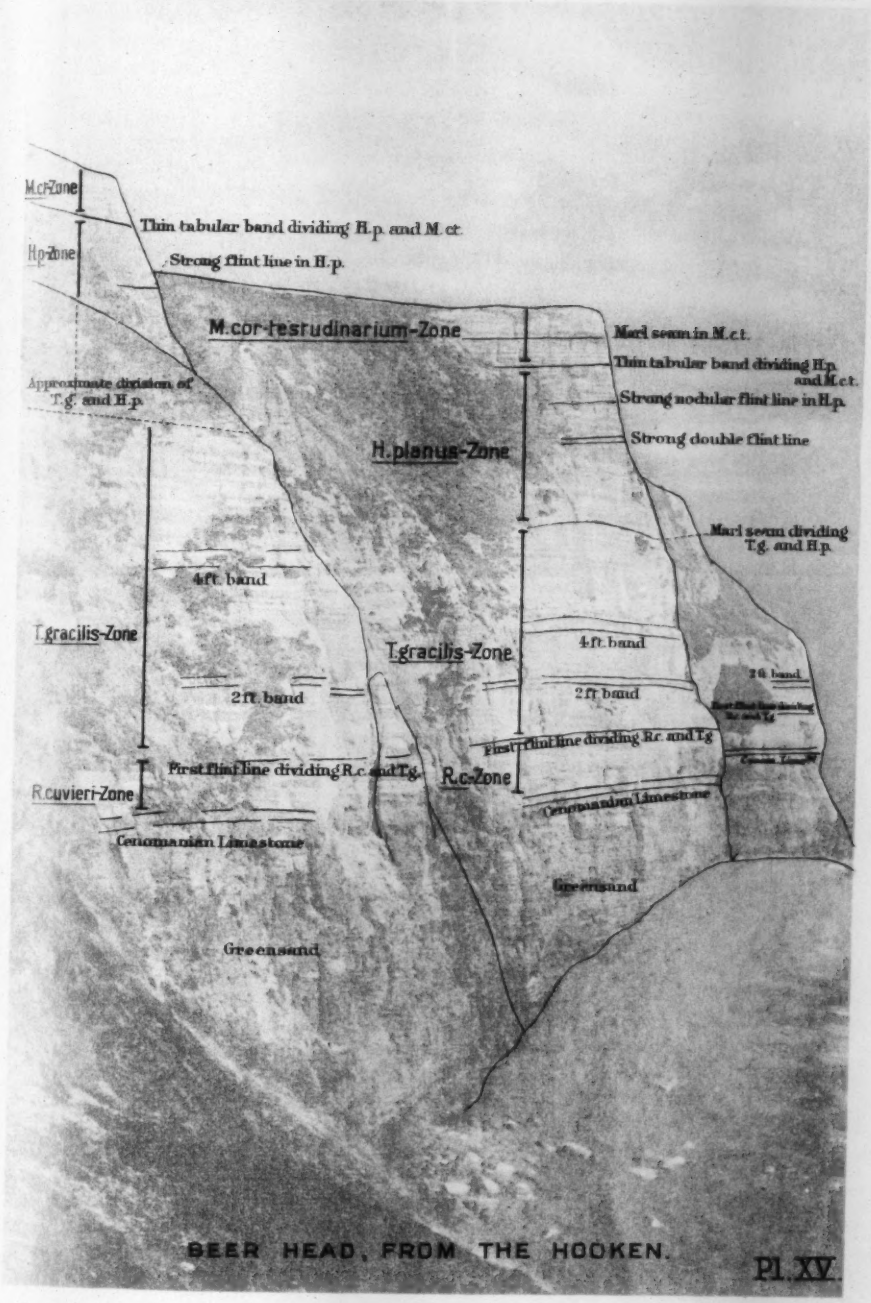
Dr. Rowe commences with an excellent description of the cliff-section from White Nothe to Bats Head, which comprises all the zones of the Middle and Upper Chalk from the zone of *Rhynchonella Cuvieri* to that of *Actinocamax quadratus*. He points out that the layers of yellowish green-coated nodules which had been called 'Chalk Rock' really occur in the upper part of the *Terebratulina* zone, and in no way represent the Chalk Rock. To my own knowledge it is just the same in the Isle of Wight; in both areas the equivalent of the Chalk Rock is to be found in the lower part of the zone of *Holaster planus*, which consists of nodular chalk without any beds of hard limestone. Each zone in the White Nothe section is defined by the range of its characteristic fossils, and of the *Act. quadratus* zone no less a thickness than 320 feet comes in without any sign of the still higher zone of *Belemnitella mucronata*, although that is found inland.

The zonal details of all the other accessible cliffs are treated in the same way, i.e., those of Durdle Cove, Man of War Cove, Lulworth, Mupe Bay, Arish Mell, and Worbarrow Bay; and though in some places the Chalk is so crushed that measurements are of small value, the determination of the zones which enter into the composition of these cliffs carries our knowledge much beyond that of any previous memoir. Finally, the cliffs which extend from Ballard Point to Studland Bay are described as fully as the difficulties of access will permit, and the limits of the zones of *Marsupites*, *Act. quadratus*, and *Bel. mucronata* in them are for the first time correctly indicated.

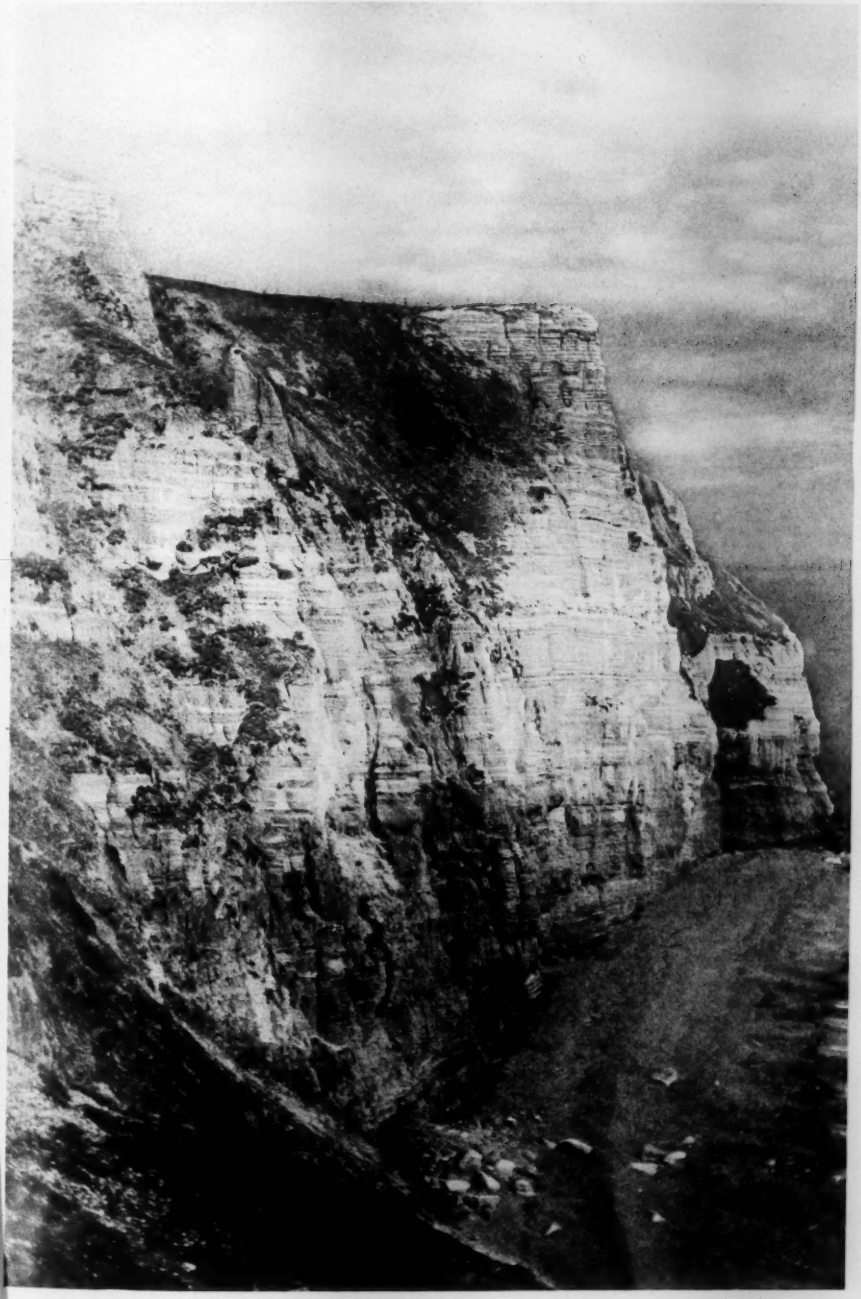
Part III of these studies, being a description of the Chalk of the Devonshire cliffs, was published in May of this year, and is in some respects the most interesting, as it is certainly the most fully and beautifully illustrated of the series, for it includes twelve plates showing portions of the cliffs between Lyme Regis and Branscombe, and each is made illustrative of the zonal geology by means of a key-slip.

The general stratigraphy of the Devon Chalk has been known since the publication of Professor Barrois' "Recherches" in 1876, for he was the first to ascertain that the greater part of the Lower Chalk is absent, and that the beds which include the Beer Stone belong to the Turonian or Middle Chalk. More detailed and accurate knowledge of the structure of these cliffs has been in my possession for many years, but being destined for a Geological Survey memoir its publication has been long delayed. Meantime Dr. Rowe has visited the coast, and has explored the beds in some places more minutely than I was able to do, the result being an excellent guide to the Chalk of Devonshire.

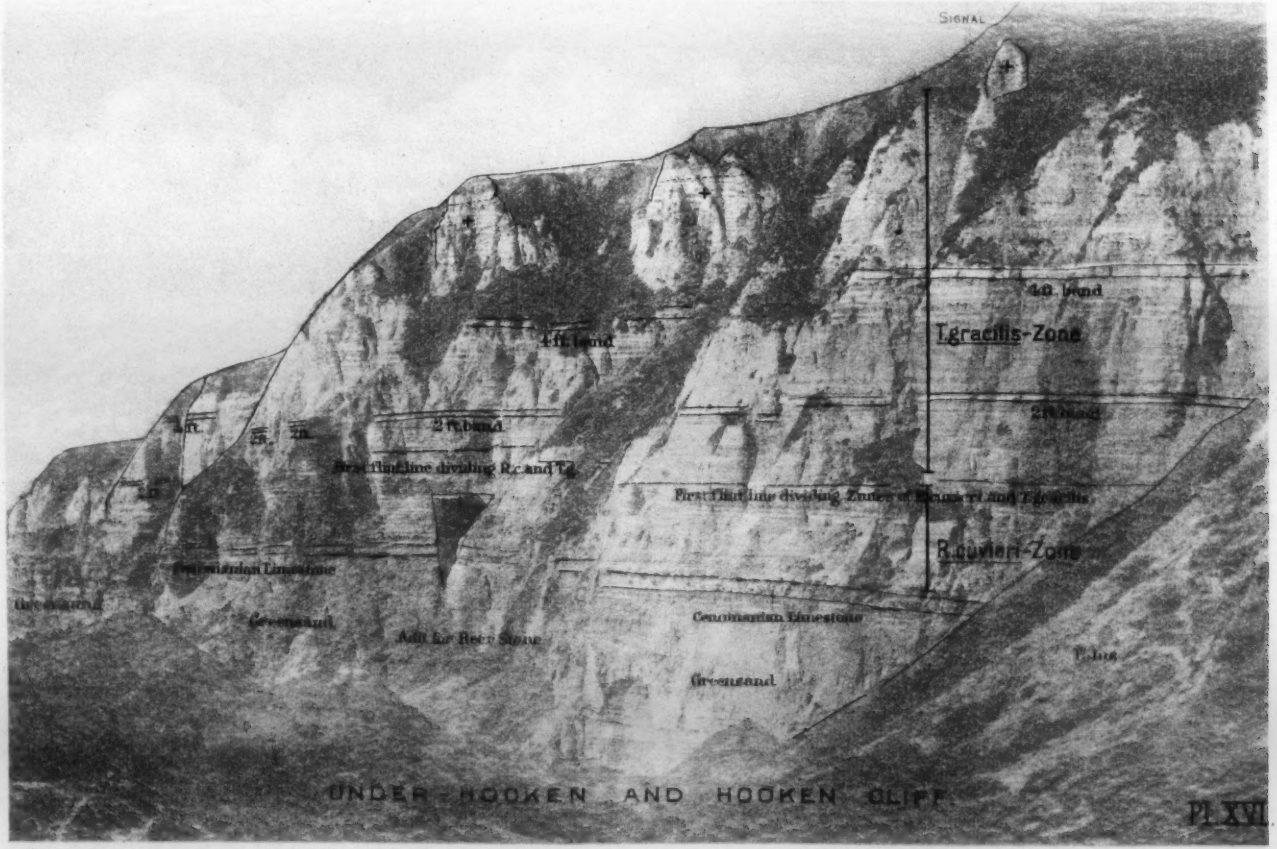
Beginning with the Pinhay cliffs near Lyme Regis, he shows that they exhibit good sections of the zones of *Rhynch. Cuvieri*, *Ter. gracilis*, *Hol. planus*, and *Micr. cortestudinarium*, and his careful collecting of fossils has enabled him to delimit the zones in this section more accurately than any previous observer. The same succession is found again at Beer and at Beer Head, and I agree with him that the summit of the zone of *Micraster cortestudinarium* is not




Beer Head, from the West.

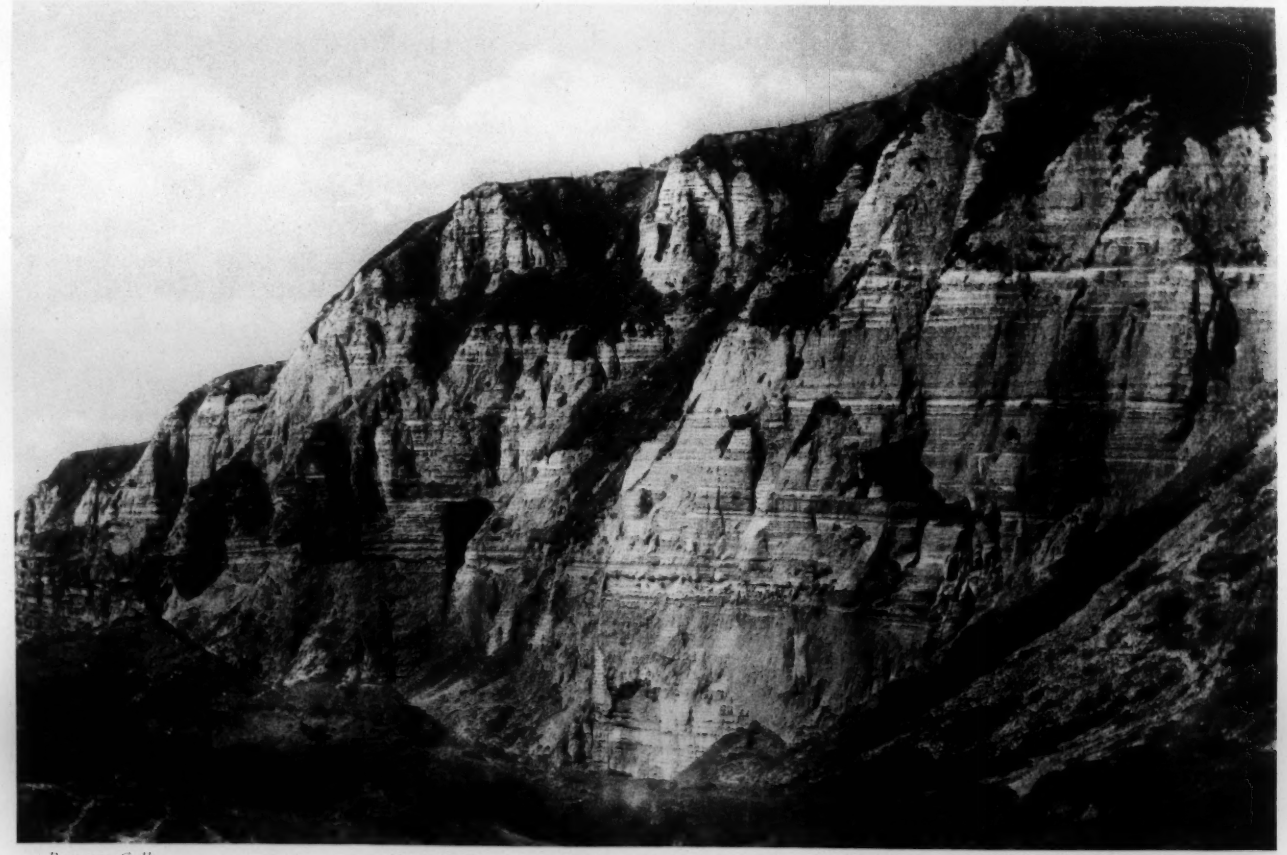


*Bemrose, Collo.* BEER HEAD, FROM THE WEST.




Bemrose Collo.

UNDER HOOKEN AND HOOKEN CLIFF, FROM THE EAST.



*Bemrose Collo.*

UNDER HOOKEN AND HOOKEN CLIFF, FROM THE EAST.

reached at any place along this coast, and that evidence of the higher zones is only to be found in the flints of the overlying gravels.

The interesting section of Beer Head and Hooken Cliff is fully described, and is illustrated by four plates which are excellent both from an artistic and geologic point of view. Of these plates our readers will be able to judge from the two examples which are here introduced. The first (Plate XV) is a view of Beer Head itself, a sheer cliff of nearly 300 feet in height, of which Dr. Rowe says, "no section on this coast gives one so diagrammatic of the zonal boundaries as Beer Head, for none is so complete." The second (Plate XVI) shows the Hooken Cliff, behind the great Southerndown landslip; this rises to a height of 400 feet, and presents a face of beautifully weathered beds. Here, by means of a convenient talus-slope, a continuous section can be examined through a large part of the Middle Chalk, the Cenomanian (24 feet thick at this point), and the upper half of the Selbornian (Upper Greensand). At this locality one of the most interesting phenomena is the local break and gradual disappearance of certain beds in the western part of Hooken Cliffs. Dr. Rowe is quite correct in stating that about 70 feet of Chalk is missing above Mitchell's Rock, but he is mistaken in thinking that the whole of the Cenomanian is also absent; I found the basal part of the Cenomanian limestone both in Martin's and in Mitchell's Rock, and particulars of the beds which compose these fallen masses are given in a memoir which is on the eve of publication. I also differ from Dr. Rowe in his reading of the zones in the Berry Cliffs. But these are minor points and do not detract from the great value of his paper. Like each of the other papers, it concludes with a 'zoological' summary and with a tabulated list of fossils showing the zonal distribution of each species.

The careful and thorough manner in which Dr. Rowe has worked the South Coast sections merits our hearty recognition, while the illustrations are deserving of the highest praise. It is satisfactory to know that the Chalk cliffs of Yorkshire will soon be similarly described and illustrated.

For the benefit of those who are not members of the Geologists Association, it may be mentioned that each of Dr. Rowe's papers can be purchased separately from Mr. E. Stanford, the price of Part I being 1*s.* 6*d.*, that of Parts II and III being 3*s.* each.

A. J. Jukes-Browne.

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Memoirs of the Geological Survey of England and Wales.

II.—The Geology of the Country near Leicester (Explanation of Sheet 156). By C. Fox-Strangways, F.G.S. 8vo; pp. vi and 122, with 15 text illustrations. Printed for H.M. Stationery Office. London: E. Stanford, Long Acre (or of Messrs. Dulau & Co., 37, Soho Square, W.), 1903. Price 3*s.*; price of Sheet-Map 156, colour-printed, 1*s.* 6*d.*

THANKS to the energy of the Director, Mr. J. J. H. Teall, there has been a steady output of memoirs by the staff of the Geological Survey, as may be seen by reference to this and to the June Number of the GEOLOGICAL MAGAZINE (pp. 269–277).

In the present memoir, by Mr. C. Fox-Strangways, we have a description of the geology embraced in the area contained in Sheet 156 of the new series one-inch Map of England, which covers parts of central and eastern Leicestershire and a part of Rutland. Considerable changes have been made in the delineation of the geology of this part of the Midlands, due principally to the use of larger scale maps, which has enabled the outcrop of the granite and other older rocks in the neighbourhood of Mountsorrel to be shown with more exactness than was possible on the old maps of smaller scale. The outcrop of the Rhætic beds has also been traced, and slight modifications have been made in the mapping of the Keuper Marl; the subdivisions of the Middle Lias, too, are now shown with greater precision.

The Drifts, which cover so large an extent of the area embraced in this map and memoir, have been surveyed in detail for the first time; they form the most striking feature of the map, and well exemplify their plateau-like character.

The alluvium, both in the main and smaller valleys, has been carefully and accurately traced, and tends to bring out more clearly the drainage system of the country. The river terraces are also shown.

A new feature, which will be observed on the colour-printed map, is the introduction on the margin of a longitudinal section from south-east to north-west, showing the general structure of the ground, taking in the Charnwood rocks and Mountsorrel Granite in the north-west, with the Keuper Marls about Syston, followed by the Rhætic beds and Lower Lias Limestone and shales, with the Middle Lias sandy shales and rock-bed resting on it, and also occasional outliers of Inferior Oolite forming the high ground of Robin-a-Tiptoe, Whatborough Hill, and other eminences (see also page-section given at p. 5 of memoir). Everywhere between the main valleys and their tributaries the Great Chalky Boulder-clay, with intercalated beds of sand and gravel, together with the Upper and Lower Older Boulder-clay, cover the country in wide sheets. The district is thus essentially a clay country, the Keuper Marls, Lias Clays, and Boulder-clay all contributing to its argillaceous character, and influencing its soils from an agricultural point of view.

The older formations that come to the surface within the limits of the map occupy a very small space, but they have been proved to extend further beneath the newer rocks at Leicester and elsewhere. They include a small outcrop of the pre-Cambrian slates of Bradgate Park and the intrusive granite and other rocks of Mountsorrel, which form the fringe of the Charnwood Forest district. The principal formations, however, are the Trias and the Lias, which practically cover the whole of the district.

The following table gives a list in descending order of the subdivisions of the strata :—

| | | | |
|---|---|---|---|
| Recent and Pleistocene. | Recent and Post-Glacial. | | Alluvium. |
| | | | River-gravels. |
| | Glacial. | | Valley-drift. |
| | | | Chalky Boulder-clay, with intercalated beds of sand and gravel |
| | | | Older Boulder-clay (upper part). |
| | | | Quartzose sand. |
| | | | Older Boulder-clay (lower part). |
| | | | Older sand and gravel (?). |
| Jurassic. | Inferior Oolite. | | Northampton Sands. |
| | Lias. | Upper Lias. | Shales. |
| | | Middle Lias. | Marlstone rock-bed (zone of *Ammonites spinatus*). |
| | | | Sandy shales and clays with ironstone, etc. (zone of *Am. margaritatus*). |
| | | Lower Lias. | Lower Lias shales, with limestones in the lower part. |
| Triassic. | Rhætic. | | Rhætic beds. |
| | Keuper. | | Keuper Marl with lenticular sandstone beds, and bands of gypsum. |
| Pre-Cambrian or Archæan. | Charnian. | | Granite of Mountsorrel, and associated rocks. |
| | | | Slates, hornstones, and agglomerates of Charnwood Forest. |

The Keuper Marl crops out along the Soar Valley, covering a considerable area, but the most extensive formation is the Lower Lias, which crosses the centre of the district; between these is a narrow band of Rhætic shales, which has now been mapped for the first time. This is followed by the Middle and Upper Lias, which cover the eastern part of the district, and form the higher ground found in that direction. A few isolated hills of Inferior Oolite rise here and there above the general mass of the Upper Lias Clay. Finally, the whole of these strata are more or less covered by Boulder-clay and sands, which have somewhat altered the general character of the country.

The soil of the country, being in the main derived from the underlying formations, is mostly clay of a very retentive character. It is diversified here and there by beds of sand and gravel, which render it much lighter. This is particularly the case with the alluvial gravel that occurs along the margin of the Soar Valley, especially about Syston. In the eastern part of the area the rock-bed of the Middle Lias, where not covered by Drift, also forms a light rubbly soil, which is the best arable land in the district. In consequence of the large proportion of heavy clay land the greater part of the country is devoted to grazing purposes, and is noted for its extensive pastures and its excellence as one of the finest hunting countries in the kingdom.

Although there is no coal-mining in the area now under consideration, the proximity of the coalfields to Leicester, and their early connection by one of the first railways made in the kingdom, have enabled that town to become an important manufacturing centre.

A large industry, and one which has greatly increased of late years, is the quarrying of roadstone. This is actively carried on at Mountsorrel, where the granite forms an excellent material both for mending roads and for pavements; it is also used in the preparation of artificial flagstones. These quarries are very extensive, and being connected by branch lines with both the Midland and Great Central Railways, a large amount of road-metal is sent away to other districts.

The Keuper Marl is extensively used along the Soar Valley for the manufacture of bricks, and has entirely superseded those made from the Glacial and Liassic Clays, which were worked to a small extent locally for this purpose.

The rock-bed of the Middle Lias contains a certain amount of ironstone and was formerly worked at Tilton, but it does not appear to have been profitable.

Gypsum occurs in the Keuper Marl at Thurmaston, and other bands have been met with in borings; but it has not been used commercially in this district, although extensive works exist to the north between Kegworth and Gotham.

The limestone bands in the lower part of the Lias, from which the well-known cement at Barrow is made, are worked for lime at Kilby Bridge, but the beds are more shaly and impure than at Barrow.

Building-stone is also a scarce article, the Lias rock-bed being generally too soft and friable for the purpose. The Middle Lias yields some hard fossiliferous blocks (called 'jacks'), which have been used on the Melton and Market Harborough Railway in the construction of bridges, which appear to stand fairly well.

A carefully prepared catalogue of fossils obtained from the Trias, Rhætic, and Lias formations of Leicestershire and Rutland (pp. 95–115), giving the range and localities for each, will be found of great use to the palæontologist.

A long list of borings and well-sections is recorded. There are two well-printed half-tone plates: (1) "Hawcliff Hill, Mountsorrel, Crags of Granite, showing horizontal bedding"; (2) "Railway Cutting at Tilton, showing Upper Lias Shales resting on the Rock-bed of the Middle Lias." The other thirteen illustrations are in the text (a few of them being from Professor J. W. Judd's memoir "Geology of Rutland," prepared in the age of woodcuts).

The new map (No. 156) of which this memoir is a description is one of the best and most successful examples of colour-printing yet issued by the Geological Survey; the arrangement of the colours (which of course corresponds with the general arrangement of the drainage-lines of the country) giving this sheet a most pleasing and artistic appearance, the colours producing a very harmonious effect.

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III.—The Geology of the Country around Reading; being the Explanation of Sheet No. 268. By the late John Hopwood Blake, Assoc. M. Inst. C. E., F. G. S., with contributions by

Wm. Whitaker, B.A., F.R.S. Edited by H. W. Monckton, F.L.S., F.G.S. 8vo; pp. 92, with 13 illustrations in the text. Printed for His Majesty's Stationery Office by Wyman & Sons. London: E. Stanford, Long Acre (or Dulau & Co., 37, Soho Square, W.), 1903. Price 1*s.* 6*d.*

THE author of this memoir, Mr. John Hopwood Blake, joined the Geological Survey in 1868, and worked in Somerset, Suffolk, and Norfolk until 1884, when he removed to Reading and was for many years occupied on the re-survey of that neighbourhood, giving special attention to the Drifts, which before had only been partially mapped. He then proceeded to Oxford, where he laboured on, having nearly completed the MS. of this memoir at the time of his death, March 5th, 1901.

The geology of the Reading area has been rendered classical as the scene of some of the early labours of Prestwich, the fine sections of the mottled plastic clays, so long worked as tile-earth, having led him to adopt the name 'Reading Beds' for the varied group of strata which here intervene between the Chalk and London Clay. The district is one in which the action of rivers and changes in their courses are conspicuously shown, a subject which has been dealt with by Mr. H. J. Osborne White and others, but requires to be discussed in relation to a much wider area than is covered by this Sheet (No. 268).

Mr. H. W. Monckton, who has devoted much labour for many years to the elucidation of the Bagshot Beds and the Gravels of the Thames Valley, has kindly undertaken the task of editing Mr. J. H. Blake's MS. for publication, and, whilst retaining all Mr. Blake's notes, he has freely inserted additions from his own notebook, especially in the chapters relating to the superficial deposits, for which Mr. Monckton may thus be considered to some extent responsible. The map, it is to be regretted, has not at present been printed in colours, but two editions, with and without Drift, were issued in 1898 *hand*-coloured. We hope the superior colour-printed map will shortly be obtainable for this district.

The country around Reading embraced in Sheet 268 represents an area of 216 square miles; that portion on the north of the Thames being in Oxfordshire, and the remainder in Berkshire, with the exception of a somewhat irregular narrow strip along the south, which is in Hampshire. Reading, the capital of Berkshire, is situated near the central part of the area. The area is drained by the River Thames and its tributaries, the Pang, the Kennet, and the Loddon, together with minor streams.

The following is a list of the geological formations which are shown on the map by distinctive colours:—

| | |
|---|---|
| Recent ... ... ... | Alluvium.<br>Tufa. |
| Pleistocene ... ... | Loam.<br>Valley-gravel.<br>Clay-with-flints and loam (overlying the Chalk).<br>Plateau-gravel.<br>Pebble-gravel. |

| | |
|---|---|
| Eocene ... ... ... | Upper Bagshot Beds.<br>Bracklesham Beds.<br>Lower Bagshot Beds.<br>London Clay.<br>Reading Beds. |
| Cretaceous ... ... | Upper Chalk.<br>Middle Chalk. |

Only the Middle and Upper Chalk come to the surface in this district, but at Winkfield, in Windsor Forest, a boring passed through the whole formation, and the thickness was found to be 725 feet, of which 219 feet was Lower Chalk, 169 feet Middle Chalk, and 337 feet Upper Chalk.

The Chalk exists throughout the district, but is only found at the surface over a comparatively small part, for, in the southern half of the area and in parts of the northern half, it is covered by Eocene strata often of great thickness, and in other parts the Chalk is hidden under beds of Drift.

The Middle Chalk is divided into two zones, namely:—

2. The zone of *Terebratulina* (*gracilis*? var. *lata*, Eth.).

1. The zone of *Rhynchonella Cuvieri*, D'Orb.

The zone of *Terebratulina* consists of smooth white Chalk, and in it nodules of flint are *occasionally* found. It has been termed the zone of *Terebratulina gracilis*, but it is now known, through the researches of Dr. F. L. Kitchin, that this species does not occur below the uppermost division of the English Chalk. The name to be used for the species of *Terebratulina* in the Middle Chalk has yet to be decided; it has been called *T. gracilis*, var. *lata*, by Mr. Etheridge.

The *Middle Chalk* runs down the Thames Valley from Goring and Streatley by Basildon to Pangbourne. Details of the several exposures of this division are given on p. 8 by Mr. Jukes-Browne.

The *Upper Chalk* consists of soft white Chalk, more or less evenly bedded, with numerous irregular nodules of flint along the planes of bedding, and sometimes in the Chalk itself between the planes. Thin seams of tabular flint occasionally occur along the bedding-planes, or fill fissures or joints inclined at various angles to them. At its base is the *Chalk Rock*, a cream-coloured limestone with glauconitic grains and many green-coated nodules.

The Upper Chalk is divided into several zones, only the three lower of which have been identified in the Reading district, namely:

3. The zone of *Micraster coranguinum*, Leske.

2. The zone of *Micraster cortestudinarium*, Goldf.

1. The zone of *Holaster planus*, Mant.

(1) The zone of *Holaster planus* includes the Chalk Rock, which, as has been said, forms the base of the Upper Chalk. The average thickness of this zone in the Thames Valley is about 20 feet. Several localities and sections are recorded, e.g., an old quarry facing the Thames in Harts Lock Wood opposite Basildon, and in the road-cutting on White Hill, east of Goring.

(2) The zone of *Micraster cortestudinarium*, Goldf. The average thickness of this zone in the Thames Valley is about 60 feet, and

there seems to be some thickness of Chalk exposed in several pits which is referable to it. Part of the zone is well exposed in the railway cutting west of Pangbourne, where the beds are bent up into a slight anticlinal curve, of which a sketch is given.

(3) The zone of *Micraster coranguinum*, Leske. Along the valley of the Thames the thickness of this zone is about 200 feet. Exposures in quarries are numerous from Whitchurch to Shiplake, and probably all belong to the same zone.

At Mapledurham and Chazey Farm, at Caversham, and south-east of Wargrave in Berkshire, similar exposures of this zone can be seen. Chalk is exposed in most of the valleys in the north-western part of the area, and the fields are in many places thickly covered with flints.

*Reading Beds.*—There is a great break in time between the Chalk and the Reading Beds, which are here found resting upon it; for not only are the highest beds of the Chalk wanting in this area, but a considerable series of Eocene strata which in other places is found below the Reading Beds is also absent. The Reading Beds accordingly here lie upon a greatly but evenly eroded surface of the Chalk.

The whole formation in this area varies from about 70 feet or less to 90 feet in thickness, and is composed of variously coloured mottled plastic clays and more or less loose sands; the clays are the upper part, and vary from 30 to 50 feet in thickness, the sands forming the lower part, being from 20 to 40 feet thick. The 'bottom bed' consists of stiff dark bluish-grey clay from 7 to 10 feet in thickness.

The main mass of the Reading Beds extends beneath the surface in the southern half of the district, and at its outcrop forms a narrow band running nearly due east and west. There are also several outliers resting on the Chalk to the north, some to the north and others to the south of the Thames. These are described in detail.

Mr. W. Whitaker contributes many notes full of valuable information on sections, well-sinkings, and borings. A section given, fig. 9 (p. 29), is taken from Sir J. Prestwich's paper (Quart. Journ. Geol. Soc., 1854, vol. x, p. 88) on the Basingstoke and Newbury Branch Railway; and one by Whitaker, fig. 10, at Rose Kiln, south of Reading, giving excellent exposures of the Reading Beds.

The famous bed of fossil Oysters (*Ostrea bellovacina*, Lmk.) had, it appears, attracted attention before 1699, and in a letter from Dr. Brewer to Dr. Sloane (see Phil. Trans., 1700–1, vol. xxii, p. 485) the writer mentions that this remarkable deposit had been "exposed over an area of between five and six acres of land, resting on a hard rocky Chalk, the stratum of greensand with oyster-shells being nigh two feet deep."

Dr. Buckland (in 1817), Robert Plot, author of the "Natural History of Oxfordshire" (1705, p. 120), Dr. Wm. Stukeley, "Itinerarum Curiosum" (1724, p. 59), and other writers are

referred to who had observed this interesting geological deposit. Mr. E. T. Newton, F.R.S., contributes some notes on plants from the Reading Leaf-bed, first described by Sir J. D. Hooker (Quart. Journ. Geol. Soc., 1854, vol. x, p. 163).

The London Clay (pp. 42–52) is next dealt with, and a list of the fossils of the Basement Bed is added. Then follows a description of the Upper Bagshot, Bracklesham, and Lower Bagshot Beds (pp. 53–59). The Clay-with-flints and Pebble-gravel are described in a separate chapter (pp. 61–62), followed by the Plateau-gravel, which forms extensive layers often 20 feet in thickness, from 160 to 500 feet above the sea-level.

The memoir ends with an account of the Valley-gravel, Loam, and Recent deposits. An appendix of principal works and authors' names who have contributed to the geology of the district, and a good index, complete this useful memoir. There are thirteen illustrations in the text, ten of which represent fossils. This memoir is published at 1*s.* 6*d.* in paper wrapper.

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MEMOIRS OF THE GEOLOGICAL SURVEY OF SCOTLAND.

IV.—The Geology of North Arran, South Bute, and the Cumbraes, with parts of Ayrshire and Kintyre (Sheet 21 of the one-inch Geological Map of Scotland). 8vo; pp. viii and 200, with 10 plates and 2 figures in the text. Printed for H.M. Stationery Office by James Hedderwick & Sons, Glasgow. J. Menzies & Co., Edinburgh (or of Messrs. Dulau & Co., 37, Soho Square, London, W.), 1903. Price 4*s.*

The Description of North Arran, South Bute, and the Cumbraes, by W. Gunn, F.G.S.; Part of Ayrshire, by Sir A. Geikie, D.C.L., F.R.S.; Part of Kintyre, by B. N. Peach, F.R.S.; On the Petrography of the Tertiary Igneous Rocks of Arran, South Bute, and the Cumbrae Islands, by A. Harker, M.A., F.R.S.

THE present memoir describes the geology of the area embraced in Sheet 21 of the one-inch Geological Map of Scotland, and includes the north part of Arran, South Bute, and the Cumbraes, with parts of Ayrshire and Kintyre. The ground in Ayrshire was surveyed by Sir A. Geikie, who also mapped a narrow belt along the east coast of Arran in 1872. Bute and the Cumbraes were surveyed by Mr. Gunn, and the small area in Kintyre by Mr. Symes. The survey of the southern part of Arran was commenced in 1892 by Mr. Gunn, who gradually traced his lines northwards till he completed the mapping of the whole island; the field-work being carried on under the supervision of Mr. B. N. Peach, F.R.S. The geological description of North Arran, South Bute, and the Cumbraes has been written by Mr. Gunn, that of the Ayrshire Coast by Sir A. Geikie, and that of Kintyre by Mr. Peach. The petrography in chapter xi has been supplied by Mr. A. Harker, F.R.S. In part ii of the Appendix the notes on the petrography of the Old Red Sandstone igneous rocks have been contributed by Mr. Kynaston, and those on the Carboniferous igneous rocks by

Mr. Seymour. While the field-work was in progress petrographical notes on various rocks from this area were also supplied by Mr. Teall, F.R.S., Dr. Hatch, Professor Watts, Professor Grenville Cole, and Dr. Flett.

Considerably more than one-half (about five-eighths) of the area of this Sheet is occupied by sea, the Firth of Clyde and its branches, and the land amounts to only about 161 square miles. The land area belongs to three different counties, and consists of no less than nine separate portions, seven of them being islands or parts of islands, and the other two belonging to the mainland.

In the north-west corner of the map is a small portion (about 13 square miles) of the peninsula of Kintyre in the neighbourhood of Skipness, Argyllshire. On the eastern border is a somewhat larger area (about 16 square miles), part of the county of Ayr. It embraces a strip of coast-land stretching from Largs to near Ardrossan, together with the Horse Island opposite to its southern end. The remaining portions belong to the county of Bute. Near the northern edge of the map occur four of these—the southern parts of the islands of Bute and Inchmarnock, the whole of the Little Cumbrae, and nearly all of the Great Cumbrae. The largest land mass is the northern portion of Arran, nearly three-quarters of the whole area; and the northern end of Holy Island, which closes in Lamlash Bay, completes the list. The extent of coastline in the Sheet is about 91 miles.

*Physical Features.*—Naturally, from the small size of the separate portions of land, there can be no large streams, but some of the ground rises to a great height, especially in the Isle of Arran. The Kintyre portion is an undulating tableland rising rapidly from the sea-level to a height of 500 or 600 feet, and the highest point is Cruach-an t-Samhlaidh, which reaches to 849 feet above the sea. This area is drained by the Claonaig Water and the Skipness Water. Inchmarnock is a low rocky island of less than 200 feet in elevation. The western side of Bute rises to 279 feet above the sea. Birgidale Butts is 400 feet above the sea. In South Bute the highest points are Suidhe Chatain (517 feet) and Tor Mor (585 feet) near Glencallum. The Great Cumbrae resembles Bute to the north of Kilchattan, and rises to a height of 417 feet above the sea. Some intrusive igneous masses, however, diversify its surface considerably. The Little Cumbrae, rising to 409 feet, is rocky like South Bute, and has a series of gently sloping terraces. On the Ayrshire side is the rocky promontory of Portincross, 456 feet above the sea; much of the border of the Sheet is over 800 feet and at one place exceeds 1,000 feet in height.

The fine peaks of the northern granite mountains, with their deep-cut glens, are the dominant feature of the scenery of Arran. These are contained within a circular area, about 8 miles by 7 across. All the principal streams take their rise in this mass or from a smaller area on the southern edge of the sheet. Some of the chief hills are Ard Bheinn (1,676 feet), A'Chruach (1,679 feet), and Beinn Breach (1,649 feet). Nearly all the highest hills are

round or flat-topped. Beinn Bharrain (2,345 feet) and Beinn Bhreac (2,333 feet) are the highest points of a continuous ridge; Meall-nan-Damh (1,870 feet) and Meall Mor (1,602 feet) are isolated conical hills. The streams from these drain west of Loch-na-Davie and north down Glen Catacol.

From the masses of Caisteal Abhail (2,817 feet) and Cir Mhor (2,618 feet) diverge ridges that embrace the glens of Sannox and North Sannox, which drain eastwards, and that of Rosie, which drains southwards, into Brodick Bay. More than twelve peaks in these high ridges exceed 2,000 feet. Goatfell, the highest summit in the island, which attains to 2,866 feet, is on a continuous range of high ground over 2,000 feet in elevation, which runs in a curved line from Cioch-na h-Oighe (2,168 feet), round the head of White Water, past Goatfell, some half-mile down its southern spur. The fine panoramic photographic view from the top of Goatfell, looking north, forms the frontispiece (plate i) of this memoir. It shows admirably the continuous high ridge running in a curved line, on which the so-called north top of Goatfell stands up and forms a prominent peak. For three-quarters of this distance the ridge is nearly everywhere over 2,500 feet, and only falls slightly below that height at one or two points. A ridge which bounds the White Water on the north runs eastward to Am Binnein (2,172 feet). Holy Island is steep and rugged, and rises to above 1,000 feet in height.

Only an outline is attempted of the very complicated geology of the northern part of the Isle of Arran, which forms the bulk of the land in this Sheet, fuller details being reserved for a complete memoir on the island. The principal additions to our knowledge of the geology of Arran made during the progress of the Survey are:—The discovery of the former extension of Cretaceous, Liassic, and Rhætic formations in the island from the presence of fragments of these rocks enclosed in a Tertiary volcanic vent. The definite determination of the Triassic age of the sandstones, conglomerates, and marls of the southern part of Arran, and their unconformability to the Carboniferous rocks. The restriction of the Carboniferous formation to an extremely narrow compass in the island, a much broken and faulted strip which does not extend to the west coast, and the discovery in it of strata of Coal-measure age. The discovery of beds of probably Arenig age in North Glen Sannox in the form of black schists, cherts, and grits, associated with old lavas and volcanic tuffs similar to those occurring near Ballantrae in Ayrshire. The discovery of no less than six different sets of volcanic rocks in addition to that formerly known as occurring in the lower part of the Carboniferous formation. Of these newly discovered volcanic series one is probably of Arenig age, two belong to the Old Red Sandstone period, two are of Carboniferous age, and the newest, which is a huge volcanic vent, is probably of Tertiary age. The age and character of the numerous intrusive rocks, both acid and basic, have also been definitely fixed, and their distribution more accurately determined. While the majority of the intrusive rocks

are of Tertiary age, a considerable number belong to the Carboniferous period and some to that of the Old Red Sandstone, while a few are as old as the Lower Silurian period, or even earlier in date than this.

In chapter ii is given a table of formations occurring in Sheet 21, and a general geological description of the area. The following is a Table of the Aqueous Series observed :—

| | | |
|---|---|---|
| Recent and Post-Tertiary. | Subaerial and Fresh-water. | Blown sand. |
| | | Alluvium of stream terraces and old lakes. |
| | | Peat. |
| | Estuarine and Marine. | Mud and sand of present beach. |
| | | Raised beaches (25 feet). |
| | | Raised beaches (intermediate). |
| | | Raised beaches (100 feet). |
| Drift Series. | Sands, gravels, and stratified clays. | |
| | Eskers and glacial shell-beds. | |
| | Erratic blocks. | |
| | Boulder-clay or Till ; drumlins. | |
| | Ice-markings on rocks. | |
| Cretaceous. | Limestone with siliceous concretions, occurring in volcanic vent. | |
| Liassic. | Dark shale with many fossils, occurring in volcanic vent. | |
| Rhætic. | Black shale with ironstone and limestone, occurring in volcanic vent. | |
| | Pale-coloured mudstones, occurring in volcanic vent. | |
| Triassic. | Red marls and shales, with white and yellowish sandstones. | |
| | Thick red, yellow, and whitish sandstones, with masses of conglomerate. | |
| | False-bedded red sandstones. | |
| Carboniferous. | Coal-measures, with contemporaneous lava. | |
| | Carboniferous Limestone Series. | Upper Limestone group. |
| | | Edge-coal group. |
| | | Lower Limestone group. |
| | Calciferous Sandstones, with intercalated volcanic series. | |
| Old Red Sandstone. | Upper Red Sandstones and conglomerates, with volcanic series. | |
| | Lower Red Sandstones, mudstones, and conglomerates, with volcanic series. | |
| Lower Silurian. | Cherts, grits, and dark schists, associated with a volcanic series (Arenig ?). | |
| Metamorphic. | Mica-schist. | |
| | Limestone. | |
| | Slate. | |
| | Gritty schists, or schistose grits. | |

The Igneous Series are divided into :—

A. Those which are interstratified or contemporaneous with the formations among which they lie : occurring in the Carboniferous, in the Old Red Sandstone, and in the Lower Silurian.

A[1]. Fragmental volcanic rocks subsequent in date to the strata among which they lie : of Tertiary age.

B. Intrusive or subsequent in date to the rocks among which they lie : of Tertiary, Carboniferous, Old Red Sandstone, Lower Silurian (?), and of uncertain age.

The most effective illustrations of geological structures are given in the ten plates which illustrate this memoir, and deserve special notice. Plate ii furnishes an admirable photo-reproduction of an exposure of contorted mica-schist with quartz-veins, seen in the

shore-cliff opposite Imachar, two miles north of Dougrie, Arran. Plates iii and vi illustrate 'pillowy' structures in Arenig and Carboniferous lavas in Arran. Plates iv and v illustrate unconformability in Upper Old Red Sandstone and Lower Carboniferous rocks. The other plates illustrate false bedding in the New Red Sandstone, jointing in granite, a Tertiary dolerite dyke traversing New Red Sandstone, moraines in Glen Cloy, and a landslip.

This is a very full and interesting memoir, and contains, as will be seen from the title and introduction, contributions by many writers upon a great variety of subjects, although igneous and volcanic rocks and their microscopic structure occupy a large share of its pages. The appendices comprise: (1) Palæontology, by B. N. Peach, F.R.S.; (2) Petrography, by H. Kynaston and H. J. Seymour; (3) Bibliography.

The list of fossils have been prepared by Mr. B. N. Peach, Dr. C. B. Crampton, Dr. Traquair, Mr. Kidston, Dr. Wheelton Hind, Mr. E. T. Newton, and Mr. Tait. An index appropriately completes this very useful memoir on a most difficult and complex country, but one, upon which many geologists have expended their best energies to unravel and explore, from the days of Pennant (1794) and Hutton (1795) to Sir A. C. Ramsay, who made a model of the Island of Arran (in 1840–41), James Nicol (1852), Sir A. Geikie (1873 and 1897), and Wm. Gunn (1901–1903).

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V.—An Orographical Sketch of Korea. By B. Kotô, Ph.D. Rigakuhakushi, Professor of Geology, Science College, Imperial University, Tôkyô, Japan. [The Journal of the College of Science, Imperial University of Tôkyô, Japan, 1903, vol. xix, Article 1, pp. 62. 4to; 3 plates and large folding Geotectonic Map of Korea (plate iv).]

KOREA is an Asiatic kingdom, consisting mainly of a peninsula lying to the north-east of China, between 34° and 43° N. lat. and 124° and 131° E. long., being 600 miles from north to south and 135 miles from east to west, with an area of about 80,000 square miles. Its coastline is roughly estimated at 1,740 miles, and its size is slightly under that of Great Britain, with a population of 10,528,937.

"Korea," says Professor Kotô, "is the Italy of Eastern Asia. It stretches out from the main body of Manchuria in a southerly direction between the *cul de sac* of the Yellow Sea and the Sea of Japan, both being fringing seas, as Italy projects between the Adriatic and the Mediterranean.

"On the north and north-west the Korean peninsula is bounded by a well-defined topographic feature, the equatorial range of Chyang-păik-san, and a southerly lying basin drained by the Amnok-Gang[1] and the Tu-man-Gang.

[1] This is the Ya-lu-Kiang of the Chinese and signifies the *duck-green river*, from some resemblance in the colour of the river water to that of a duck's neck. *Gang* or *kang* signifies in the Korean language 'large,' and *chhyŏn mul* or *nai*, 'small' streams.

"Similarly, the peninsula of Italy is limited on the north by the Alps and the plain of the Po. Both peninsulas stretch about 10 degrees meridionally; Korea from 33° to 43° North lat., Italy from 36½° to 46½°. They lie, as we have seen above, in nearly the same latitude of the Temperate zone, and enjoy an agreeable, transitional climate, neither too wet nor too dry. Both are inhabited by peoples of very ancient culture.

"However similar in their general outlines there are yet many points of dissimilarity, especially in regard to their internal geological components and structures and their external land forms. Italy is not wanting in young geologic formations, while Korea is in the main built up of Archæan and Palæozoic rocks. Though both curve a little to the east, Korea is mountainous on the side of the Sea of Japan and rather flat towards the Yellow Sea, while in Italy the Apennines run along the axis of the country.

"This Asiatic Italy, fitly called by W. E. Griffis the 'Land of the Hermit Nation,' was secluded from the rest of the world for a long time, and even her old neighbours, the Japanese and the Chinese, were strictly and vigilantly prevented from penetrating into the country. It is a unique patch of the earth's surface, a *terra incognita* in all respects, excepting eight free ports and the two inland towns, where over 20,000 Japanese and men of other nationalities have made themselves at home, but know nothing of what lies a few kilometers from them in the interior. Only a few Westerners have made trips into the country and studied the land and its people."

Lately, Professor Kotô twice made journeys in the peninsula, in 1900–1 and 1901–2, extending over 14 months, travelling over the interior in a caravan with six men and four ponies, marching 20 kilometres daily, and covering 6,300 kilometres in these trips, crossing and recrossing the peninsula from one shore to the other in nearly equidistant lines so as to enable him to obtain a general idea of the land formation and geology of the country.

Professor Kotô found that only two previous explorers had made reliable reports on the country, namely, Professor v. Richthofen and Dr. C. Gottsche, whose works serve to give a general idea of the geography and geology of the peninsula.

Professor Kotô thus summarises his orographical sketch of Korea (p. 54):—"The Archæan formation, composed, as elsewhere, of gneiss-granite, gneiss, and mica-schists, is thrown into broad, undulating folds on the front side of the peninsula, in the western portion of the Han-land and Paleo-Chyo-syön, becoming steeper as we go south. The axis of folding stretches from S.S.W. to N.N.E. or from S.W. to N.E. Two prominent crests of this type are the No-ryöng and Chhya-ryöng ranges, which extend obliquely across Chyöl-la Do and Chhyung-chhyöng Do. Besides, many small swellings of the crust surface can be seen in the Paleo-Chyo-syön Land, though deeply hidden under the mask of Paleozoic formation. Nearly half of the area of the peninsula is occupied by folds of this class. These specialized folds should be classed, according to my

view, with the Sinian System of South China . . . . The broad belt of the Sinian System which obliquely crosses the Korean peninsula, if extended beyond the Tung-hai, will join with the mountains of South China, to which the name 'Sinian System' was originally given by Pumpelly."

Richthofen's ideal line runs from South Japan to Fuchou, and then along the coast of Fokien and Kwang-tung, as seen in H. Fischer's map of East Asia. (E. Debes' Neuer Handatlas, No. 44.)

The greater portion of the Sinian System of South China, of which Ta-yü-ling forms the axis, enters the Tung-hai between Fuchou and Shang-hai, and its further prolongation will correspond well, both in its direction and its breadth, to those which I venture to call the Sinian folds of Korea. If these Sinian folds of Korea be prolonged to the north-east, a greater part of the folds will again unite directly with the tectonic lines of the Sichota-alin, as they are given in Ivanow's work.[1]

The Sinian represents an old system of crustal folds in the peninsula, and contemporaneously with it, or a little later, there was generated another system in the Liautung direction in the Kai-ma Land, which was posthumously faulted in serial order towards the south, producing three parallel ridges (Myo-hyang-san, Työk-yu-ryöng, and Kal-eung-nyöng). These trend from W.S.W. to E.N.E., and form apparently the direct continuation of South Manchuria. Another line (the well-known Chyang-păik-san) stretches east and west, obliquely meeting the preceding in the basin of the Tu-man-Gang.

Professor Kotô names the complex of uplifted edges and sometimes of folds, running in a north and south direction along the axis of the peninsula, the 'Korean System.' It is so characteristic of this region that even native geographers long ago recognised its great importance in the surface features of the peninsula. This and many other minor groups are described and mapped in detail by the author (on pl. iv), who also furnishes profile sections in the text and nine process photographs (in three plates) giving views of the most striking features of the country.

Professor Kotô writes remarkably good English, and his orographical descriptions are interspersed with pieces of information about the people and the scenery of Korea. Here is a sketch:—"Diamond Mountain, Keum-gang-san (1,200 metres = 3,900 feet), is a large granitic stock [or intrusion] penetrating paleozoic rocks. It is excavated to its bottom by a crooked canyon-like gorge, the precipitous walls of which overhang the bottom and rise in a multitude of grotesque pinnacles; hence the mountain is usually called that of Twelve thousand peaks (Plate i, fig. 1). The valley and its steep slopes are forested with pine (*Pinus pinea*) and maples, through which clear water rushes down in thousands of cataracts. About 15 pagodas large and small have been here since the

[1] "La chaîne du Sikhota-Aline," p. 112. Explorations géologiques et minières le long du Chemin de fer de Sibérie, Livraison xvi. St. Pétersbourg, 1898.

Sil-la period, some perched on rocky heads, some buried deep in the forest, giving shelter to world-renouncing monks and nuns. It is the Yosemite of the Korea, and a favourite resort of Westerners." (p. 18.)

"A high plateau, Kai-ma land, on the north has a precipitous front towards Manchuria; the incurves of Korea Bay on the west and of Chyo-syön Bay (Broughton Bay) on the opposite side give some idea of a boundary as expressed in coast lines, and we can trace it in the interior as well. In 1033 Tök-chong, the 9th king of Ko-ryö, ordered his subject Yu-syo to build a stone-wall 25 feet high and thick, across the peninsula so as to check the incursions of *Nuchens* and *Chitans* from the Manchurian frontier, perhaps after the model of the Great Wall of China constructed B.C. 220 by Shi-hwang-ti of the Tsin dynasty to ward off the inroads of *Huing-nu* from Inner Mongolia." (p. 32.)

"During my journey" (says Dr. Kotô) "I saw no continuous wall which might be looked upon as the ruin of this fabulous engineering work, but I frequently passed strong stone gates at strategically important points, such as at the foot and on the passes of the mountains. The Koreans are still very nervous because of their past sufferings, for they have to fear enemies from both north and south." (The northern enemy is not mentioned, but evidently Russia is hinted at! whose Siberian railway terminus is at Vladivostok, Amur Bay, long. 132° E., lat. 43° N.)

"From the south they have to guard against the encroachments of the Japanese. Travellers will see the towns fortified all along the south-coast, and in these intermural hermit-towns the people seek in vain a peaceful life."

It is quite evident that we shall hear more of the exploration of Korea within the immediate future.

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VI.—On Batrachian and other Footprints from the Coal-measures of Joggins, N.S. By G. F. Matthew, LL.D., F.R.S.A. [Bull. Nat. Hist. Soc. New Brunswick, vol. v, No. xxi, 1903.]

IN this article are described some footprints of small Batrachians from the Nova Scotian Carboniferous. The largest is referred to King's genus *Thenaropus*, and compared with *T. heterodactylus*, King, and *Anthracopus ellangowensis*.

The two smaller tracks are referred respectively to Marsh's genera *Baropus* and *Dromopus*. They are well preserved, and show continuous series of footmarks. The first of the two has claws on most of the toes, but the second appears to have been devoid of claws.

There is also a track made by a small arthropod, which had a double series of claw marks on each side of the trail.

The species described in this paper are *Thenaropus* (?) *McNaughtoni*, *Baropus unguifer*, *Dromopus celer*, and *Myriapodites*, sp. A half-tone plate gives a good representation of these fossil footprints.

# REPORTS AND PROCEEDINGS.

## I.—The Geological Society of London.

I.—May 27th, 1903.—Edwin Tulley Newton, Esq., F.R.S., Vice-President, in the Chair.

The Secretary read a letter from the President, expressing his regret that he would be unable to preside at the remaining meetings of the Session, as, in obedience to the orders of his doctor, he was obliged to take a complete holiday from all work for the next few weeks.

The following communications were read:—

1. "An Experiment in Mountain-Building." By the Right Hon. the Lord Avebury, P.C., F.R.S., F.G.S.

Various observers have endeavoured to throw light on the origin of mountains by compressing pieces of cloth, etc. In these cases, however, the pressure was only in one direction. The author wished to obtain a method of obtaining compression in two directions at right angles to one another; and, accordingly, he had an apparatus constructed, consisting of four beams of wood, which could be approximated by means of screws. In the space, 2 feet across and 9 inches in depth, were placed pieces of carpet-baize and layers of sand, each about $1\frac{1}{2}$ inches deep. The beams were then caused to approach one another until the sand rose in the centre into contact with the glass cover, against which it was flattened out. Casts were made of the surfaces of the different baize-layers, and it was found that in the lower layers the ridges were narrower, shorter, more precipitous, and more broken up than in the higher layers. A second series of casts was exhibited, with the sand and baize having been arranged as before, but with the weight placed on one side. The ridges followed the edges, though not closely, leaving a central hollow. There was a difference between the higher and lower layers, similar to that seen in the first experiment.

2. "The Toarcian of Bredon Hill (Worcestershire), and a Comparison with Deposits elsewhere." By S. S. Buckman, Esq., F.G.S.

The Upper Lias (G 3) of Bredon Hill is shown on the Geological Survey map as more than 300 feet thick, whereas at Wotton-under-Edge it is said to be only 10 feet thick. But at the former locality the Inferior Oolite is represented as resting directly on Upper Lias, while at the latter the 'Midford Sands' intervene. It is shown that this 'Upper Lias' at Bredon contains strata of the following hemeræ:—*Lilli, Variabilis, Struckmanni, Dispansi, Dumortieriæ*, and *Moorei*, in addition to those of the hemeræ *Falciferi* and *Bifrontis*, which at Wotton have been called Upper Lias, where the rest have been mapped as the 'Midford Sand.' These sands are 210 feet thick, and hence the Toarcian strata of the two places are 220 and 380 feet thick respectively. Thus the so-called

'Upper Lias' is really the equivalent of the Upper Lias, Cotteswold Sands, and Cephalopod Bed of the Cotteswolds; of part of the Junction Bed, the Upper Lias, and Bridport Sands of the Dorset coast; and of the Toarcian of Normandy. Measured thicknesses of the strata at four localities in the Cotteswolds are given, and sections to show that an anticline was formed, and penecontemporaneous erosion took place at Birdlip before the *Scissi* hemera. A table of comparative thicknesses of deposits laid down during similar times in the Cotteswolds and Dorset is also given, and a section of the Toarcian at May-sur-Orne, and of the Toarcian and Aalenian strata at Tilly-sur-Seuilles (Calvados), where the Toarcian is reduced to a thickness of only some 23 feet. The chronometry of the Toarcian is discussed, and the approximate maxima of deposit formed during the hemeræ *Falciferi* to *Moorei* are given, amounting to a total of 719 feet. This time is divided into nine hemeræ, so that the time-value of a hemera is equal to the average time taken to deposit about 80 feet of strata. A concluding table gives the sequence and correlation of the following deposits:—The Cotteswold Sands, the Sands at Sodbury, the Midford Sands, those of Cole (Somerset), the Yeovil Sands, the Bridport Sands, and the Northampton Sands.

3. "Two Toarcian Ammonites." By S. S. Buckman, Esq., F.G.S.

Two Ammonites belonging to the family Hildoceratidæ, found by members of the Cotteswold Naturalists' Field Club, are described and named. The allies of both species have been figured in the "Monograph of Inferior Oolite Ammonites." One is near to *Denckmannia torquata*, but the degenerative change begins at an earlier age, and it soon shows marked decline of ornament of which that species gives little information. Its date of existence is probably hemera *Variabilis*. The other is a platygyral costate degenerative of *Chartonia binodata*; the inner whorls should be the morphic representations of that species, the outer whorls show a costate stage which is the general rule of decline from a tuberculate stage. Notes are given explaining the technical terms employed.

The Council have awarded the proceeds of the Daniel Pidgeon Fund for 1903 to Dr. E. W. Skeats, F.G.S., of the Royal College of Science.

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II.—June 10th, 1903.—J. J. H. Teall, Esq., M.A., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "On Primary and Secondary Devitrification in Glassy Igneous Rocks." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., and John Parkinson, Esq., F.G.S.

Part I.—By John Parkinson, Esq.

In this part the types of primary devitrification as found at Obsidian Cliff are briefly reviewed, with the order in which they

appear in the crystallizing glass. 'Porous spherulites' are once more mentioned, in order to call attention to the 'feather-like' crystals which often distinguish them, and of which an explanation is given in Part II. Reference is made to the conditions which favoured primary devitrification at Obsidian Cliff; and the author, leaving general principles to be discussed in the second part, mentions one or two special types of primary devitrification. These are concerned with the probable formation of eutectic zones, or patches; either following the crystallization of an overplus of any given material, or as a residuum. After a brief reference to secondary devitrification, this part of the paper concludes with a summary in which the several relations of secondary to primary devitrification structures are given.

Part II.—By Professor T. G. Bonney.

Crystallization in a colloid mass involves an orientation and commonly a separation of the molecules; a process illustrated in an early stage by the formation of microliths in a glass, and the devitrification of the latter when it is heated without actual melting, or by a metal becoming crystalline under strains. Certain conditions, such as slow cooling, supersaturation, and the presence of inclusions—anything causing discontinuity—are favourable to crystallization, some special cases of which are discussed in the paper. The structures thus formed in rocks may be classified as (1) the linear and (2) the granular; and the former may be subdivided into (*a*) the rectilinear, (*b*) the curvilinear. Spherulitic structure in its simpler form falls under (*a*), and is at first little more than a radial grouping of molecules, the process becoming, as described, gradually more complicated. Of this, 'graphic' or 'pegmatitic' structure is a final stage, where two minerals are crystallizing out of a solution, and one has slightly the advantage over the other, so that it virtually forms a skeleton crystal. Into this the ordinary radial growth of a spherulite may be seen to pass; likewise also examples of (*a*) into those of (*b*): the latter being due to the 'leading' mineral meeting with a rather stronger resistance, as if a crystal were forming in a very tough jelly. An experiment of Messrs. J. I'Anson and E. A. Pankhurst (Min. Mag., vol. v, 1884, p. 34) on the formation of tubes of colloid silica from a fluid alkaline silicate, affords a good illustration of this curvilinear growth. Resistances, as the author has pointed out in an earlier paper, are favourable to actinolitic and branching growths, and the various types of structure mentioned above can be shown to be dependent on them.

The granular structure is next discussed, and explanations are offered of its varieties. This, on a microscopic scale, is often a result of devitrification, where (so far as is known) there has been no marked rise of temperature; and the author shows how this is affected by greater or less freedom of molecular motion, discussing also cases in which a crystalline mass, like a spherulite, has undergone a later rearrangement.

In conclusion, the relation of some of the structures to an eutectic composition is discussed. It is not, however, easy, owing to the complexity of the conditions, to come to any very definite conclusions in the case of old rock-masses.

2. "Geology of the Ashbourne and Buxton Branch of the London and North-Western Railway: Crake Low to Parsley Hay." By Henry Howe Arnold-Bemrose, Esq., M.A., F.G.S.

The present paper is a continuation of one published in 1899, and deals with the geology of the next eight miles of this railway. After passing through Yoredale Shales in the second cutting (No. 10), the railway enters the thick beds of Mountain Limestone, in which it continues as far as Buxton. The latter rock is frequently folded, and owing to this no very great thickness of limestone is seen. It was not found possible to correlate the beds in the different cuttings. The following cuttings are described:— (9) Crakelow Farm, (10) Newton Grange, (11) Moat Low, (12) New Inns South, (13) New Inns, (14) Alsop-en-le-Dale, (15) Nettly Low, (16) Cold Eaton, (17) Cheapside, (18) Bank House, (19) Heathcote, (20) Hand Dales, (21) Caskin Low, (22) Lean Low, and (23) Parsley Hay; and measured sections are given of several of them, with an account of the folding and other features displayed. The Newton-Grange cutting shows 6 feet of tuff, probably a thin representative of the 140 feet seam in the Tissington cutting. The limestones are in places granular, oolitic, or dolomitized, and microscopical accounts are given of the several varieties, as well as of the encrinital limestones, pellets, and pebbles in the limestones, and the calcareous tuff.

## II.—Mineralogical Society of London.

Mineralogical Society, June 9th.—Dr. Hugo Müller, F.R.S., President, in the chair. Mr. H. F. Collins gave an account of a remarkable mass of wollastonite with associated minerals which occurs at Santa Fe, State of Chiapas, Mexico. This mass of nearly pure wollastonite covers an area of 400 × 160 yards, and extends to a depth of more than 300 feet; it is surrounded on all sides by granite, felsite, and other igneous rocks, and is separated a mile from the nearest limestone. Near the outskirts of the mass occur extremely large crystals of wollastonite, most of which have been partially or entirely converted into quartz or semi-opal. Here are also found masses of garnet and of workable copper-ores containing gold and silver. The author exhibited and described specimens of wollastonite, bornite in wollastonite, bornite in chalcedony, gold-bearing linnæite, idocrase rock, and a remarkable intergrowth of bornite and galena resembling graphic granite.—Professor H. A. Miers gave an address, illustrated by lantern-slides, in which he described the extremely interesting results which he had obtained from the observation of the growth of crystals by a new method. The method consists in tracing the changes of angle upon a crystal during its growth by measuring it at intervals by means of a specially devised inverted goniometer, without moving it from the solution in which it is growing. It was found that a octahedron of alum

yielded invariably three images for each face, so that the crystal had really the form of a very flat triakio-octahedron. Similar observations on other crystals lead to the conclusion that the faces of a crystal are in general not faces with simple indices, but vicinal planes slightly inclined to them, which change their inclination during the growth of the crystal. By determinations of the refractive index of the solution by means of total reflection within the crystal it was found that in each case the liquid in contact with a growing crystal is slightly supersaturated.

## III.—Zoological Society of London.

Zoological Society of London, June 16th, 1903.—F. Du Cane Godman, Esq., D.C.L., F.R.S., Vice-President, in the Chair. Dr. A. S. Woodward, F.R.S., exhibited photographs by Dr. Otto Herz, illustrating the discovery and exhumation of a Mammoth in the Government of Jakutsk, Siberia. He also made remarks on the specimen, which has now been mounted in the Zoological Museum at St. Petersburg under the direction of Dr. Salensky.—Dr. H. Woodward, V.P.Z.S., F.R.S., read a communication from Miss Dorothy M. A. Bate giving a description of the remains of an extinct species of Genet from a Pleistocene cave-deposit in Cyprus, named *Genetta plesictoides*, n.sp., of which the following is an abstract:—In October, 1901, Miss Bate began her search for Pleistocene bone caves in the island of Cyprus, and in the following January first discovered Dikomo Mandra, a cave containing an extensive deposit of hippopotamus remains and the largest deposit of bones found in the Kerynia range of limestone hills in the north of the island. This proved to be the only cave in which the remains of any carnivorous animal were found, other than those of the fox still living in Cyprus. The remains consist of a left mandibular ramus, only lacking the second molar and canine and a few other bones. On comparing this ramus it appears to be that of a carnivore nearly allied to *Genetta genetta*, which is still found living on the opposite shores of Palestine. On the other hand, it also presents many similarities to *Plesictis Croizeti* of the Oligocene deposits of France. The Cyprus fossil agrees with and at the same time differs from both *Genetta genetta* and *Plesictis Croizeti*, and that so impartially that it is a matter of extreme difficulty to decide with which group it ought most properly to be associated. The scanty material adds to this uncertainty, which would probably be removed were the skull and upper dentition of this species known. However, in consideration of its much more recent age compared with that of the Oligocene fossil, it is proposed, at all events for the present, to include it among the genets under the name of *Genetta plesictoides*, n.sp. The mandibular ramus is intermediate in size between that of *G. genetta* and *P. Croizeti*, and the teeth also differ in several respects from both these species. The author has been unable to find a record of any fossil *Genetta*, and among the rest of the Viverridæ the only species of Pleistocene age appears to be *Viverra Karnuliensis* from India.

## CORRESPONDENCE.

### THE GEOLOGY OF BIARRITZ.

Sir,—In your pages of August last I described the reversal of Pyrenean geology at Lourdes and Biarritz effected by M. Carez in elaborate coloured sections of the *Bull. Soc. Geol.* for 1896, p. 379. By a typographical error, the map of the intermediate Pyrenees obtained from me by M. Carez in 1885 is referred to 1865. In spite of the studied condemnation of the reply of M. Carez to the geologist who had supplied his facts, I succeeded in re-establishing the Cretaceous age of the rocks represented as Middle Silurian and Cambrian, in which hundreds of Cretaceous Ammonites had been familiar to me for thirty years.

At Biarritz the supposed Lias, simultaneously figured in the same manner, has given birth to a unanimous selection of that locality as a type and proof of those Alpine paradoxes similarly created by MM. M. Bertrand, Carez, L. Bertrand, Bergeron, Seunes, and other officials of the French Survey. The question has been reduced to the decisive test of a boring of 104 metres deep, which boring has exactly proved the contrary of the views in question as figured by M. Bergeron in *Bull. Soc. Geol.* of 1900, p. 24. This boring has exactly confirmed my predictions of the same Bulletin, p. 614, as well as the detailed sections which I furnished to those interested at the Sorbonne. An elaborate attempt to explain away this decisive boring has been presented by M. L. Bertrand in *Bull. Soc. Geol.*, 1902, p. 83; and all his alleged facts have been refuted by M. Seunes in the *Compte Rendu* of the meeting of the same society on 6th April last.

The documents enumerated will enable any geologist to judge the method applied at Biarritz by the authors of the same paradox in the Alps, Montagne Noire, Provence, Corbieres, and such Pyrenean localities as Salies du Salat and Lasseube. Eight months of recent observation in the Alps, and repeated study of the other localities mentioned, have convinced me that Biarritz has been correctly selected by all the authors in question as a perfect sample of their work. The entire problem is precisely similar to that already settled at Lourdes.

In the hands of M. Seunes the problem attains the final stage of the process of proof invariably employed. This geologist is really familiar with the ground. In 1886 he was sent to me with a letter from the last two Professors of geology at the Sorbonne, begging me to supply him with my unpublished data, and promising that my published work should be the basis of his Thesis. Starting with all the new facts collected by my assistants and myself, he has completed his knowledge by yearly work. Consequently he has admitted, after 16 years, that every supposed fact cited as proving the presence of Trias at Biarritz is absolutely erroneous. Yet he affirms the correctness of the theory left standing on exploded fallacies alone. If he did not do so, his work would be treated as my own numerous papers, and as those in the *Bull. Soc. Geol.* of 1893 by the Staff

Officer who for ten years revised the topographical maps. That officer's practice in accurate mapping and my own practice in responsible engineering work compelled each of us to leave the Société Géologique when required to divorce theory from fact. Under Elie de Beaumont such divorce was inevitable, in the opinion of the new and exactly contrary school. Those trained to repeat either formula find the one as little embarrassing as the other. In all the localities already mentioned, I have found that admitted fallacies originated the paradoxes which survive. So at Biarritz the imagined Trias originates a fresh fallacy for each disproved. In the Alps, seven fresh paradoxes have already been imagined to justify the one found untenable by itself.

For more than thirty years I have been familiar with the presence of abundant gypsum, red marls, ophite, and granite in the Cretaceous to the south of Biarritz. The Trias theory rests entirely on their assumed absence. The intrusive granite has this year been exposed by extensive engineering works at St. Jean de Luz. In 1873 I took to Paris a conclusive series of specimens from the same point. Had I then presented them, I should have been boycotted from every society and periodical. I have found similar intrusions abundant in the analogous rocks of Italy, Switzerland, and Greece. But in the *Bull. Soc. Geol.* of 1902, p. 499, M. Carez again elaborately proves the absence of granite intrusions familiar to me along 200 metres just east of the bridge of Salies du Salat; and the source of M. Bertrand's speculations at Biarritz is the fact that he has described as exotic granite, at Lasseube, a common feature of the decomposing diabase of the Pyrenees. Palassou corrected the same blunder in 1819. The demand for local accuracy and experience was still active during my apprenticeship, and I owe to it whatever real information I possess. The present ideal is realized by the man who can describe an entire continent where he has never set foot. If any geologist without the taint of local knowledge, or the stigma of repeated success in quashing reckless assertion, would study the abundant literature of the Biarritz problem, he might do much to stem the torrent of garbled compilation that drowns all useful work in the most accessible of European chains. His observations might gain a hearing on the ground that their refutation should be easy. Mine are too well known to be unanswerable, and thereby only describable as polemics. That word, and the prompt substitution of one reckless fallacy for another, appears to console my opponents and satisfy their admirers.

P. W. Stuart-Menteath.

St. Jean de Luz, *May* 5, 1903.

P.S.—On the road to Iholdy, at two kilometres south-west of St. Palais, the granite-like ophite, long known at Lasseube, can be seen rising from beneath extensive Upper Cretaceous; and many similar cases forbid the assumption of superficial carting where the relations are obscure. The nature of the Biarritz problem can be understood from my map in *Comptes Rendus de l'Académie des Sciences* of June, 1894.

THE CHART OF FOSSIL SHELLS FOUND IN CONNECTION WITH THE SEAMS OF COAL AND IRONSTONE OF N. STAFFORDSHIRE.

SIR,—In reading Mr. Walcot Gibson's review[1] I was astonished to see it stated that "marine organisms are represented as occurring on three horizons," and also that the marine band above the Gin Mine has been omitted.

Writing with the Chart before me, and having personal knowledge of the bands, I should like to correct what seems to me an unaccountable error on the part of Mr. Walcot Gibson, who is usually so accurate in his statements. The fact is that eight distinct and separate marine bands are denoted, and moreover the Gin Mine is represented by figures.

The following are the horizons represented on the Chart as marine beds, viz.:—

1. Bay Coal Band.
2. Priorsfield Band.
3. Gin Mine Band.
4. Single Two Feet or Moss Cannel Band.
5. Weston Sprink Band (horizon doubtful).
6. Seven Feet Banbury Band.
7. The Wetley Moor Coal Band.
8. The Four Feet or Crabtree Band.

I should like to call attention to another point, to which I should have expected Mr. Gibson specially to have referred. Various attempts have been made to correlate the seams of the several districts of this coalfield, generally on lithological or sequential evidence. On this Chart the seams of the whole coalfield have been successfully correlated for the first time, the marine bands forming sure data lines.

E. P. TURNER.

ASHWOOD TERRACE, LONGTON, STAFFS.
*25th May*, 1903.

## OBITUARY.

### SAMUEL CHADWICK.

BORN 1845. DIED MARCH 18, 1903.

THE death is announced of Mr. Samuel Chadwick, who was one of the founders of the Malton Field Naturalists' Society, and devoted many years to the collection of fossils from the Jurassic and Cretaceous formations of East Yorkshire. He left his native county early in life to engage in sheep-farming in New Zealand, but he returned after a few years and resided for a long period at Malton, where his business afforded him numerous opportunities of prosecuting the geological studies in which he was deeply interested. His early colonial experiences led Mr. Chadwick to emigrate again to New Zealand with his family in 1895, and he died suddenly last March at Moastone Park, Waikopiro. His remarkable collection of

[1] GEOL. MAG., May, p. 226.